Manual for the Commercial Pond Production of the African Catfish in Uganda

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Cover Page Photo
Sampling a catfish monoculture grow-out pond under static water management, fed complete diet commercial sinking pellets at Naluvule Fish Farm, Wakiso District, Uganda.
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PREFACE

A fish pond is one of the several production units used in fish farming to grow fish. The purpose of commercial fish production is to grow fish FOR PROFIT. Therefore, a farmer using ponds to commercially produce fish must:

i. ensure optimal conditions within the pond that will enable fish to grow efficiently,

ii. provide the fish with the correct nutrition to grow within a stipulated production period, and

iii. have a production plan that matches the marketing strategy.

Consequently, this manual spells out guidelines for the commercial production of the African catfish in ponds for farmers in Uganda in consideration of the following:

Fish farming is not a traditional agricultural practice in Uganda. The majority of fish farmers in the country have not yet fully understood the fundamental principles of fish farming or how these should be applied to their production management. Their ability to interpret situations as well as other related information is therefore limited. Farmers have therefore found it difficult to sieve through what information is most appropriate for their circumstances and to adapt aquaculture production technology appropriately. This has resulted in the majority of fish farmers not being able to match management with realistic yields, thereby failing to achieve anticipated yields and returns from the technologies they adopt.

Therefore, the scientific principles upon which this technology package is based are explained so as to enable farmers to make appropriate adaptations based on their resources, opportunities and constraints. In addition, care has been taken to answer questions that were commonly asked by fish farmers during the USAID FISH Project’s interaction with them in its training sessions, trials, demonstrations and field visits.

It also attempts to address common mistakes and misconceptions found during the project’s interaction with farmers with a view of helping farmers get onto the right track and improve the production and management of their enterprises. Hence, the package and recommendations developed were in addition based on actual data obtained from the project’s demonstration and trial farms. The results of the package are therefore locally achievable. This means that farmers can make realistic business plans and projections.
This manual only covers catfish production from the fingerling stage to table size. It does not discuss any aspects of catfish hatchery management for seed production.

How to use this manual

It is intended that the manual be a handbook that farmers can easily refer to and use as a quick guide regularly during the course of their production. Therefore it has been written and set out in a manner that makes it easy for reading and cross-referencing. The chapters are ordered based in order of the activities (steps) one should follow if they are intending to establish and run a fish farm commercially. In some cases, details may be expressed differently in the various chapters.

The manual is set-out as follows:
• In Section I, the technology package is summarized so as to enable one do a quick overview.
• Section II explains and illustrates the principles upon which the recommendations are based and their application to the package. Results from the trials are also included to illustrate certain points.
• At the end of each chapter is a summary of the recommended guidelines - in the event that someone wants to quickly check certain procedures such as how to feed the fish. The summary guidelines are printed in light blue boxes.
• Section III focuses on running the fish farm as a business. It explains how the data obtained can be used to evaluate and plan production, business strategy and investment.
• New words are written in italics. The definitions of these words can be found in the List of Definitions.
• At the front of the of the book on red bordered paper are ‘Reasons Why Farmers Frequently Fail’ and at the back of the book, on green bordered paper are ‘Reasons Why Some Fish Farmers Are Successful’ based on farmers' own experiences as well as the projects' experiences working with farmers.
• Practices that help protect the environment and are part of the BMP’s (best management practices) are highlighted in green oval boxes.
• In the event the reader is referred to more information about a certain issue, for example, see section 3.1.2. - the first number (3 in this case) refers to the chapter, the second number (1 in this case) refers to the major section within chapter three. All numbers fall in order and numbers thereof are sub-sections of the first, second sections respectively.
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DEFINITIONS

**Acclimate**
Allowing the animal to slowly adjust to new environmental conditions.

**Aeration**
Mechanically adding air into water with the objective of increasing the levels of dissolved oxygen in water.

**Anaerobic, Anoxic**
This is a situation when there is no oxygen available.

**Appetite**
The desire for food.

**Best Management Practices**
This term is used to describe a practice considered to be the most practical means of solving a resource management problem or reducing pollution levels to those compatible with water quality goals.

**Biomass or 'Standing Crop'**
The total weight (mass) of the fish in the pond at any one time. **Critical standing crop** is the biomass of fish in the pond when the growth rate begins to slow, meaning carrying capacity is near.

**Carrying Capacity**
The maximum biomass the pond can hold for production. Growth has ceased at this point, usually due to water quality problems.

**Catfish Highway**
Channel along the bottom of the pond levee that catfish dig out and tend to hide in.

**Condition(ed)(ing)**
Holding fish without feed for a minimum of 48 hours in good quality water at the hatchery or nursery prior to their collection and transportation to the grow-out farm. The major objective of doing so it to allow the fish empty their guts in order to reduce stress to the fish and maintain water quality during transit.

**Disease**
This is the manifestation of something gone wrong. Body functions become impaired as a consequence of stress, inherent weakness or infection.

**Dumping Feed**
This is placing feed into the pond without consideration of the fishes appetite, feeding response, appropriate feed distribution to the fish nor the consequences of the effect of the quantities fed on water quality. It is often wasteful and results into high Feed Conversion Ratios (FCRs) as well as reduced profitability.

**Feed Conversion Ratio (FCR)**
The Feed Conversion Ratio (FCR) is the amount of feed it takes to produce a unit weight of fish. It is a measure of the efficiency of feed utilization. It is a critical parameter to monitor as it determines the viability of the enterprise in feed-based production systems.

**Feeding Frequency**
This is the number of times in a day fish in a pond are given food.
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<td>Fingerlings</td>
<td>Juvenile fish of 7 cm and above. Fingerlings of 10 g and above are suitable to stock into grow-out ponds directly. Fingerlings of 5 g or less should be stocked into a nursery pond first until they are above 10 g.</td>
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<tr>
<td>Flushing</td>
<td>Replacing a large portion of the water in the pond within a day or less. The objective of flushing a pond is to get rid of excess suspended as well as soluble wastes and to dilute wastes. Think of flushing a toilet.</td>
</tr>
<tr>
<td>Flushing rate</td>
<td>Usually given as the % of the pond or tank volume per time period OR the volume of water per hour or day (e.g. liters per minute, M$^3$ per day)</td>
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<td>Gaping</td>
<td>This is when fish come to the surface of the water to gulp in air in situations when dissolved oxygen levels low. For catfish adults, this gulping of air is normal and necessary for them to gain sufficient oxygen. For very small fry, this indicates stressful conditions.</td>
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<td>Grow-out Pond</td>
<td>This is a pond in which fish are reared for table to a size the market requires.</td>
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<tr>
<td>Gutting</td>
<td>Removal of the intestines and other viscera from the abdomen of the fish.</td>
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<tr>
<td>Health</td>
<td>Is the standard or typical condition of the fish, whereby its bodily functions are normal. A healthy fish functions optimally, and is free of abnormalities of stress and disease.</td>
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<tr>
<td>Live Weight</td>
<td>The weight of a whole live fish before it has been processed. Processing fish includes gutting it. Therefore, the term refers to the weight of the fish before gutting.</td>
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<td>Nursery Pond</td>
<td>This is a pond in which young juveniles are reared to the stage when they become fingerlings or stockers. Fish at this stage are extremely fragile and susceptible to predation. Extra attention is consequently given to water quality management and predation control in nursery pond management.</td>
</tr>
<tr>
<td>Optimum Ration</td>
<td>The fish feed that gives the best growth and Food Conversion Ratio (FCR). There is minimum wastage and minimum deterioration of water quality when fish are fed optimum amounts of feed, which is usually 90% of satiation.</td>
</tr>
<tr>
<td>Phytoplankton</td>
<td>Microscopic plants that grow within water. These plants give water its bluish sometimes greenish colour. Because they are suspended within the water column, they also cause turbidity of the water and subsequently depending on the quantity reduce the depth through which sunlight can penetrate through the water column.</td>
</tr>
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Pond, parts of

**Base of Dam**

The measure of the base of the dam depends on the slope.

**Dam:**

**Levee:**

**Dike or dyke:**

These all refer to the same thing. The levee (dam or dyke) is the embankment that holds the water in the pond.

**Freeboard:**

Vertical distance from the maximum water line to the top of the dam.

**Height (h):**

The height of the dam is the distance of the dyke from the base to the top (h).

**Toe:**

The point where the slope of the levee reaches the pond bottom. The inside toe refers to this point within the pond and the outside toe outside the pond on the outer embankment.

**Top Width (TW):**

The minimum top width of a dyke (between ponds) should be 1 meter. Usually, the main dyke at the deep end has greater top width than the divider dykes so as to facilitate transport.

**Production Cycle:**

This is the period between stocking and draining when fish are being raised in the pond.

**Ration:**

The amount of feed given to the fish (made available to the fish) per day. Often expressed as “% body weight per day”.

**Sampling:**

This is the removal of fish from the pond to assess their growth and health status. After the observations fish are returned to the pond.

**Satiation:**

The fulfillment of the desire for food. When fish are satiated (full), they show no interest in taking in more feed.

**Shooters:**

These are fish of the same age-group within the same population that grow much bigger than the rest. Often such fish cannibalize on the smaller ones.
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<td><strong>Standing Crop</strong></td>
<td>The total weight (mass) of fish in the pond at any one time.</td>
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<td><strong>Static Water Pond</strong></td>
<td>This is a system of pond management whereby no ‘fresh’ water is allowed into the pond during the course of production except to top up water lost by evaporation and seepage. There is no water exchange in static water pond management.</td>
</tr>
<tr>
<td><strong>Stock</strong></td>
<td>Generally refers to the fish in production within the pond or on the farm. Is also the action of putting fish into a pond.</td>
</tr>
<tr>
<td><strong>Stocking</strong></td>
<td>Putting fish seed into the pond. Stocking the pond marks the start of the production cycle.</td>
</tr>
<tr>
<td><strong>Stress</strong></td>
<td>Is an abnormal physiological condition of fish resulting when its collective adaptive responses of the fish to environmental factors approach the fish’s limit of tolerance for that factor.</td>
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<td><strong>Thermal Stratification</strong></td>
<td>This is when the temperature on the top layer of water is distinctly different from the lower layer as occurs in ponds deeper than 2 meters.</td>
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<tr>
<td><strong>Turbidity</strong></td>
<td>The degree to which light penetration through the water column is blocked. Turbidity in ponds is often caused by small particles of either clay or phytoplankton that are suspended within the water column.</td>
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<td><strong>Whole Fish</strong></td>
<td>This refers to the fish before it has been gutted i.e. before any of it body parts have been removed for whatever reason.</td>
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<tr>
<td><strong>Zooplankton</strong></td>
<td>Microscopic animals that grow within the water, the smallest of which feed off phytoplankton.</td>
</tr>
</tbody>
</table>
## Description of the Different Categories of Catfish Size

<table>
<thead>
<tr>
<th>Category</th>
<th>Length (cm)</th>
<th>Average Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fry</td>
<td>&lt;7</td>
<td>3</td>
</tr>
<tr>
<td>Small fingerlings</td>
<td>7 - 10</td>
<td>3 - 6</td>
</tr>
<tr>
<td>Medium fingerlings</td>
<td>10 - 12</td>
<td>6 - 9</td>
</tr>
<tr>
<td>Large fingerlings</td>
<td>12 - 15</td>
<td>9 - 20</td>
</tr>
<tr>
<td>Extra large fingerlings</td>
<td>&gt; 15</td>
<td>20</td>
</tr>
<tr>
<td>Stockers</td>
<td></td>
<td>21 - 100</td>
</tr>
<tr>
<td>Sub-Market</td>
<td></td>
<td>100 - 399</td>
</tr>
<tr>
<td>Table Size&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>+ 400</td>
</tr>
</tbody>
</table>

<sup>a</sup> In the year 2008, the preferred ‘table size’ for catfish in the Project’s area of operation was +600g. However this is coming down. The ‘ideal’ table size for a producer is about 400g because after the fish get to 400g the FCR increases and growth takes much longer. Some farmers currently are selling 500g catfish to their local markets. In other countries outside Uganda, 400g is the size of catfish sold for food. However, if larger sizes can fetch a higher price per kg, the farmer must evaluate the higher cost of production per kg and compare it with the higher price obtained.

*Note that people can starve their fish or feed them poorly and the fish will become long and thin (see photo below). We sometimes refer to them as "pencil-fish". In this case, the weight/length relationship listed above will not be correct.*
SECTION I

SUMMARY OF THE RECOMMENDED BEST MANAGEMENT PRACTICES (BMPs) FOR CATFISH GROW-OUT IN PONDS
Production of Table Size African Catfish in Static Earthen Pond without Aeration using Commercial, Nutritionally-Complete Sinking Pellets

A yield of 15 tons/ha to up to 20 tons/ha of table sized (400-800g) African catfish can be achieved from earthen ponds under static water management system in 6 to 10 months respectively; when the fish are fed commercial sinking pellets that are nutritionally complete (i.e. 32% crude protein level with stabilised vitamin C). Better results are to be expected with floating pellets.

In order to achieve this yield, the following management practices are recommended (Details on pages 3 to 5):

1. Proper pond construction in compliance with the recommended standards for commercial grow-out ponds. Depth of water is very important.
2. Pond preparation for stocking inclusive of water intake screening.
3. Use of quality seed and correct stocking procedures.
4. Stocking rates based on ponds carrying capacity in retrospect of the farmers desired harvest size.
5. Feed a quality nutritionally complete feed pellet and feed the fish by response.
7. Inventory control and regular sampling using the recommended techniques.
8. Proper record keeping and regular review of records during the production cycle.
9. Harvesting at "critical standing crop", before the pond’s carrying capacity has been reached and fish growth slows or ceases.
<table>
<thead>
<tr>
<th>Activity/Item</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Pond</td>
<td>(i) Well compacted pond <em>levees</em> with a slope of at least 2:1 for commercial grow-out ponds.</td>
</tr>
<tr>
<td></td>
<td>(ii) Average water depth in pond of 1 - 1.2 meters (0.8 - 1.0 m at shallow end to 1.0 - 1.5 m at the deep end).</td>
</tr>
<tr>
<td></td>
<td>(iii) Inlet pipe at least 20 cm above the pond water level and screened with a properly fitted filter sock.</td>
</tr>
<tr>
<td></td>
<td>(iv) Outlet pipe fitted with an anti-seep collar and screened correctly with cone mesh.</td>
</tr>
<tr>
<td></td>
<td>(v) <em>Freeboard</em> of about 15-30 cm. Ponds less than 400 m² can have <em>freeboards</em> of 15 cm.</td>
</tr>
<tr>
<td></td>
<td>(vi) Having a harvest basin within the pond is optional but can be quite useful at final harvest.</td>
</tr>
<tr>
<td></td>
<td>(vii) The pond must be able to drain completely for complete harvesting and drying.</td>
</tr>
<tr>
<td>2. Pond Preparation</td>
<td>(i) Remove silt from pond. Soil removed from the bottom should be put back where it came from, i.e., used to repair pond <em>levees</em>. Excess should NOT be put at the top of the dam but rather away from the ponds.</td>
</tr>
<tr>
<td></td>
<td>(ii) Ensure pond is not leaking.</td>
</tr>
<tr>
<td></td>
<td>(iii) Correctly screen the inlet and outlet.</td>
</tr>
<tr>
<td></td>
<td>(iv) Lime the bottom of the ponds, if needed, based upon alkalinity and hardness levels (especially of new ponds).</td>
</tr>
<tr>
<td></td>
<td>(v) Fill pond. Ponds should be <em>stocked</em> within a week of filling with water.</td>
</tr>
<tr>
<td>3. Stocking</td>
<td>(i) <em>Stock</em> only fish in good condition. <em>Stock</em> fish with no obvious signs of injury, excessive stress or disease that have been packaged and transported in bags with adequate amounts of oxygen or in well <em>aerated</em> tanks.</td>
</tr>
<tr>
<td></td>
<td>(ii) <em>Stock</em> based upon targeted harvest size and the pond's <em>carrying capacity</em>.</td>
</tr>
<tr>
<td></td>
<td>(iii) The minimum <em>stocking size</em> for grow-out ponds should be fish of not less than 10 cm in length or 5 grams average weight. An initial nursery phase of one (1) month, however, is recommended when</td>
</tr>
</tbody>
</table>
Fish come in straight from the hatchery before the fish are stocked into the grow-out pond. Having an initial nursery phase helps one have better control of the inventory and improves survival rates.

(iv) The targeted harvest size will be intended market size if you are not following a split production plan.

(v) The critical *standing crop* for catfish ponds of an average water depth of one (1) meter fed commercial pellets is 15 to 18 tons/ha (i.e. 1.5 to 1.8 kg/m²). The maximum feed input in such a pond is 200 kg/ha/day (i.e. 20 g/m²/day).

### 4. Pond Water Management

(i) *Static water.* DO NOT FLUSH WATER THROUGH THE POND CONTINUOUSLY. Water should only be added to ponds:

- **A** - to top up water levels, *or*
- **B** - to correct water quality problems, such as low oxygen, high ammonia, etc.

Note that continuous water flow can be expensive and, in Uganda, the water is often cold, which will reduce growth rates. Continuous water flow would thus allow for higher *carrying capacity* but require more time.

### 5. Feeding

(i) Train fish to feed in the same area of the pond.

(ii) Training fish to feed enables a farmer to see his/her fish daily throughout the *production cycle.* This is of great value when it comes to assessing the number and size of fish in the pond in between *sampling* times as well as monitoring fish *health.*

(iii) Feed fish based upon their feeding response using the catfish feed chart as a guide to estimate daily feeding needs. Pay attention to the number of meals fish of a particular size should be given per day.

(iv) Keep recommended feeding records including both the amounts given and response at each feed.

(v) Use the records continuously to evaluate feeding performance in tandem with the pond records to adjust the feeding regime.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **6. Sampling** | (i) *Sample* monthly by seining a small portion of the pond to monitor for growth.  
(ii) Calculate new feed amounts based upon the actual average fish weights obtained at *sampling*. This will help make adjustments from the predicted fish weights on the feeding chart and allow re-adjustment to the fish’s feeding requirements.  
(iii) Record data in the pond records correctly at each *sampling*. Doing so will help with inventory control as well as monitor progression to the pond’s *critical standing crop*. Zero fish growth is an indicator of the pond having reached its *carrying capacity*. |
| **7. Record Keeping** | (i) Pond and feed records must be kept correctly as recommended.  
(ii) Records of all inputs used for fish production (e.g. pond repairs, labour, fertilisers, etc.) as well as of all sales should be kept so as to calculate profit. |
| **8. Harvesting** | (i) In order to obtain the best returns, the pond should be harvested before it reaches its *carrying capacity*, at *critical standing crop*.  
(ii) The best way to harvest the pond completely is:  
  - First, check your records and know your estimated *standing crop*.  
  - Second, seine the pond one or two times to remove the bulk of the fish when the pond is still full.  
  - Third, reduce the water level about halfway then seine once or twice to remove the rest of the fish.  
  - Fourth, drain the pond completely and pick up the rest of the fish. If the pond has a harvest basin that is correctly constructed, the remaining fish will collect in the harvest basin. |
Why Some Fish Farmers Fail

1. Poor Farm Siting: Such as in a place with inadequate water supply, poor soils for pond construction (e.g. may be rocky), far away from markets and/or supplies, etc.

2. Poor farm and facility design: Ponds not compacted properly, leak a lot, may be too shallow, and consequently construction and maintenance costs become too high while optimum yields are not achieved. Poor accessibility to ponds, requiring workers to walk across difficult terrain to transfer fish from pond to vehicle or vice-versa.

3. Poor Investment Plan: Several farmers assume that to be a commercial fish farmer one must have several large ponds. Hence, they construct many ponds at once, which constrains their cash flow. Because of this, some farmers take a while to start production or may only afford to start production in one pond after all the investment.

4. Start production before knowing what management options are available or how to farm fish.

5. Start looking for the market for fish when the fish is ready for sale. Meanwhile, because they are still feeding, the pond attains its maximum loading and fish stop growing. The longer the fish stay in the pond after they have stopped growing, the smaller the profit margin.

6. Do not employ the right people. Entrepreneurs use other peoples time, i.e. employ the right people. Hiring family members who have little or no desire to learn proper fish farming techniques is a liability because most people find it difficult to dismiss them even after it has become apparent that they are the reason for the poor performance of the fish farm.

7. Manage farms by remote control or telephone. No direct involvement in production and management activities of the farm.

8. Irregular and improper feeding. This ranges from complete lack of knowledge about the nutritional requirements and feeding of
catfish to attempts at saving money by using cheap feeds. Some farmers just do not feed their fish because they think fish will grow as long as they are in water. They do not realize that like all animals, best performance would be obtained if the fish have a balanced diet and that the feed needs to be palatable, easily digestible and does not disintegrate into the water before the fish can consume it. For the same reasons that the majority of poultry farmers would not think it wise to feed layers maize bran, a commercial fish farmer should not believe they can get the best production results by feeding catfish maize bran only. If one intends to increase production and profit margins from producing eggs, then it is well known that the best way would be to feed the layers with quality layers mash and not growers mash. Likewise, fish should be fed with the correct feed of the right quality.

9. Do not appreciate that different management levels have different requirements which consequently affects stocking rates. As in cattle, for example, the management requirements and stocking rates for ranching are different from zero grazing because of the limits to which the animals reared under the different systems can get access to adequate feed to cater for their maintenance and production needs. The same applies in fish farming. Stocking rates are a function of the specific management regime.

10. Being more impressed with harvesting the few large fish rather than looking at the overall picture and appreciating total tonnage at harvest. If you had a sow that ate all its piglets and grew nice and fat; would you be happy? Or would you rather have several but smaller animals of a reasonable size for sale rather than one giant? Survival rates and average fish size matter when raising table-fish, because profit margins above operational costs generally range between 10 to 30% depending on one’s market. The net income is therefore largely a function of turnover.

11. Do not keep records and do not assess performance to re-adjust management practices accordingly after each cycle. A farmer is therefore unable to tell whether a profit or loss will have been made. Having money in one’s pocket after a sale does not imply one has made a profit. Some farmers do not want to keep records because they are scared of facing the harsh realities of a loss. Unless one is able to face the bitter truth and correct his/her
management practices, there won’t be any improvements and the business will eventually collapse.

12. Hobby farmers who keep fish in ponds forever as though they are taking care of wild-life in a game park.

13. Wrong objectives for investing in aquaculture. Some do it simply because their friends are doing it or because they are targeting ‘free’ funds from donors or government. Nothing in this world is free. Always watch out for the hidden costs before making a final decision. Furthermore, pond construction is costly and is not something one should undertake for the sake of it. Changing one’s mind and having to fill in ponds because you have changed your mind is even more costly. Think objectively before you embark on fish farming. Farm fish as a business; as a source of employment and income for yourself and others. Invest in fish farming only if you have identified it as a serious opportunity that can work out into a successful enterprise.

14. Expand the farm as a solution to low profit and yields. It is a bad business decision to expand a failing business without first finding out what the causes of the failure are and correcting them.

15. Buy high quality expensive feed but use the laziest and least conscientious person on the farm as the feeder. This is like throwing money down a drain.

16. Believe consultants and newspaper reports that indicate fish farming requires little investment and results in huge profits. If it were that easy, everyone would be doing it. And the so-called consultants would be busy making money from growing fish; not from advertising their expensive training programs.
   - Yes a person can grow fish with little investment but there will be little production in return. You can’t get something from nothing.
Section II

HOW TO IMPLEMENT THE BEST MANAGEMENT PRACTICES
INTRODUCTION

1.1. The Concept of Commercial Fish Production

The objective of commercial fish farming is to produce fish to supply markets at a competitive price and make a profit. The market is therefore, the driving force for commercial fish farming. The key parameters that determine the levels of production and success in fish farming are water quality, feed quality and seed quality. How one manages these parameters vis-à-vis the prevailing market demand and prices determines the viability of a commercial fish farm.

Figure 1.1: Hand Illustration of the Five Basic Components of Commercial Fish Farming. (Adapted from Schmittou et al., 1998)

1.2. Sustainable Aquaculture Production

The catfish production technology discussed in this manual is feed based and built upon the principles of sustainable aquaculture. Sustainable
aquaculture as applied in this technology package is *an adaptable aquaculture production technology system whose ecological and economic viability persists indefinitely* (Schmittou et al., 1998).

Fish are greatly affected by the environment in which they are grown. An aquatic ecosystem is extremely dynamic, changing with nutrient inputs, weather and season. The effects of the changes are even more pronounced in artificial systems like fish farms where man influences what organisms and other inputs are added to the culture environment. Fish growth and survival are closely related to water quality. Furthermore, fish are cold-blooded animals. All of their bodily functions are directly influenced by the temperature of the environment. So, while the markets determine aquaculture opportunity, the ecological and economical principles determine the choices for sustainable aquaculture practices and technology.

Therefore, users of the manual are encouraged to understand the principles upon which this catfish static water pond production technology is based. This is because, the specific environment where the farm is located defines what additional opportunities and constraints in production one is likely to encounter. Farmers and extension agents are therefore encouraged to be observant and continue to make adaptations, in order to enhance the productivity and profitability of their specific enterprises. Therefore, this book is but a guide to the commercial production of catfish in ponds.

1.3. General Biology of African Catfish

In nature, the African Catfish (*Clarias gariepinus*) tend to live in calm waters with vegetation. Living conditions in such an environment can be harsh. There is often a lot of organic matter in the water. In addition, in several of these locations (for example, in flood plains) the water levels fluctuate seasonally, going up during the rains and receding during the dry seasons. In several of the clarias catfish natural habitats, the water levels drop to the point whereby the water-way almost dries up. The relatively large amounts of organic matter in water coupled with the relatively slow water flows through such habitats result in low levels of dissolved oxygen in the water for prolonged periods and increased acidity of the water.

In order to overcome these environmental challenges, the fish have adapted in the following ways:
1. **Low Oxygen Levels** - Catfish have developed in addition to gills, an accessory cauliflower like organ (the arborescent organ) that enables the fish obtain oxygen from air when the oxygen levels are too low in water or the swamps have dried out. However, this organ is largely functional in adults. More than 90% of juvenile catfish oxygen consumption is from dissolved oxygen in water whereas in adults, 40% to 50% of the oxygen uptake is atmospheric (Hecht *et al.*, 1997).

2. **Body Shape and Features** - The fish have no scales, but a relatively thin skin and protective layer of mucus over the skin. Their long cylindrical shape also allows them to easily burrow into the mud when water levels drop to keep themselves moist and cool. They can only survive in burrowing if there is an air-water interface. In addition, it has *barbels* that enable it sense its food even though visibility is poor in the swamp. Its flattened mouth is designed so that it can ingest food off the bottom.

3. **Feeding Habits** - The fish is also an omnivore, meaning it can literally eat almost anything although in the wild adults preferably eat other fish, insects or other forms of aquatic animals. Adults have a *diel* (twenty four hour cycle) feeding pattern, meaning that they need to hunt once a day, subject to food availability. Consequently they have a relatively large stomach capable of holding quite a bit of food, unlike the Nile tilapia whose stomach is relative small because it is naturally a browser and feeds several times a day.

4. **Social Behaviour** - Catfish are extremely social. They tend to live, hunt in tight groups. Hunting as a pack is among their natural feeding strategies (Hecht *et al.*, 1997). They tend to dwell at the bottom.

5. The fish are able to withstand slightly acidic water.

6. The catfish also grows fast and does not become sexually mature until it is about a year old (about 600g) depending on feeding. Females become mature earlier than males.
The above mentioned attributes, make the catfish a good candidate for aquaculture. However, these biological characteristics affect the fish's production requirements and potential in the following manner:

1. **Low Dissolved Oxygen Levels** - Where the water has adequate levels of dissolved oxygen, catfish obtain their oxygen from the water through their gills. Aerial respiration in catfish is largely a compensatory mechanism for the periods when the dissolved levels of oxygen in the pond are low (Lévêque, 1997). However, in order to survive the periods of low dissolved oxygen, the fish must have access to the air otherwise they will die. In addition, the fish spend more energy obtaining oxygen from the air than they would do, when they can obtain it from the water.

In fish farming, the initial limiting factor to production as far as water quality is concerned is oxygen. Because adult catfish have the ability to overcome this by breathing air, higher carrying capacities and feed input level can be accommodated in catfish grow-out ponds as long as the build up of metabolic wastes (ammonia) in the water are kept under control and the fish can access the water surface. However, because more energy is spent when the fish obtain air from the atmosphere, **Feed Conversion Ratios (FCRs)** tend to increase, which in turn affects the profitability of the enterprise. Therefore, just because clarias catfish have the ability to withstand situations of low dissolved oxygen, for profitable production, the water quality parameters should as much as possible be maintained within the recommended ranges (see section 5.1. for more details). A minimum amount of oxygen within the water is required for the breakdown of metabolic wastes. Having more oxygen dissolved in water improves the efficiency with which the gills function which is more energy efficient for the fish and results in better growth rates.

2. **Body Shape and Features** - Because the catfish have no scales, the thin layer of mucus is the only first line of defense against infections whose port of entry into the fish is the skin. Consequently, removal of this layer of mucus through poor handling predisposes the fish to infection and illness. Catfish, should therefore, be handled with care during routine production operations.

Because catfish are bottom dwellers, most of the time within the pond they will be at the bottom unless there is a reason for them to
come up, for example, to feed or gulp air to obtain oxygen. Consequently, they tend to stir up the pond bottom which makes the water in catfish grow-out ponds muddy (i.e. turbid). Coupled with their burrowing behavior, they also dig into the sides of the pond, creating what is termed as the 'catfish highway'. This results in breakdown of pond levees, especially when they are not constructed as recommended and in addition increase levels of pond turbidity (see sections 3.1.1, 3.1.2. and 5.2.5. for more details respectively). Their body shape and the catfish highway they create in the pond enables them to easily escape seining when nets and techniques are poor. They are able to pass under and around the nets. When there is a hole at the bottom of the seine net, and one catfish finds it, because they move in hordes like sheep unlike tilapia, all the others shall be informed and they will all escape in a stream through the hole. Therefore, seine net specifications and seining technique are important; otherwise one can easily come out with an empty net.

3. Feeding Habits – The clarias catfish is omnivorous. This means it can consume a wide selection of food items that allows for a range of options in culture to provide for its nutritional needs. Because of their social hunting behaviour, it is preferable to feed them in ponds from a single place as doing so induces a feeding frenzy that results in the complete consumption of the feed, improved FCRs and reduced feed wastage. This is an important fact as above 60% of production costs are the feed cost (Hecht et al., 1997).

4. Social Behaviour – Pack hunting is a natural feeding strategy in Clarias catfish. Keeping the fish at high densities, consequently results in reduced stress and aggression while stocking at low densities results in the establishment of territories and aggression. Stocking densities in the pond should be such that:
   (i) They are high enough to the point whereby territories are not established, aggressive behaviour is reduced, feeding response is high and feed consumption time is reduced.
   (ii) Management requirements to sustain the biomass in the pond do not reach the pond’s carrying capacity limits for the specified management level (see sections 5.3. and 6.2.6. for more details).

5. Most healthy fish tend to swim against a current. Therefore, they will tend to aggregate and swim out of the inlet if water is flowing
into the pond during the *production cycle*. Thus, most escapes of catfish from ponds actually occur through the inlet (Plate 3.3). Inlets should therefore be set above the water level and well screened (see section 3.1.4. for more details).

1.4. Current Market Factors and Opportunities in Uganda and Region favouring African Catfish Grow-out Production

In addition to the favorable biological characteristics, there is both a local and regional market for the catfish which makes it also a good candidate for commercial farming.

Currently, there is a shortfall in the local supply of fish in Uganda. Catches from the country’s lakes have declined largely due to the negative effects of using under-sized fishing gear and over-fishing (Figure 1.2).

![Graph showing fish production over the years](image)

**Source:** FIGIS: 2008

**Figure 1.2:** Uganda’s total fish production over the years.

The demand for fish on the other hand has continued to rise from Uganda’s rising population as well as the increased demand from export markets. This demand is unlikely to be met by the lake fisheries because fish production from the lakes cannot sustainably be increased beyond the lakes ‘sustainable yield’ otherwise the fishery resources will be depleted. (Plate 1.1 shows a photo of mugongo wazi sold in local markets). The only feasible option of increasing fish supply to meet the
rising demand is through fish farming as it is increasingly becoming a major source of fish for the market

As a result of the low supply, local fish prices are rising (Figure 1.3). Whereas ten years ago fish was the cheapest source of animal protein in the country, it is now as expensive as beef. The current price trends are making farming fish more economically viable than it was five to ten years ago. However, the cost of inputs is also rising so the commercial farmer must closely follow prices and have contingency plans for times when input costs rise faster than market price.

![Figure 1.3: Trends in price (USh) per kilo of table size tilapia, catfish and pelleted fish feed (30% crude protein) for the period 2005-2008. (Data from USAID Fish Project; 2005 and 2006 data based upon farmer interviews; 2007 and 2008 data from sales reports)](image)

The diversity of fishes harvested from the lakes has also declined. Whereas the catfish were among the fish commonly caught, these days it is largely Tilapia, *Rastrineobola* sp. (mukene) and Nile perch and found in the local markets. The only source for large volumes of catfish now farmed catfish. Fish farms are now the major source of catfish to the processing plants in the country. Regional and International Markets for the Catfish have also been identified by processors who have started exporting farmed catfish, smoked and frozen. See Plate 1.2 that shows the various farmed catfish products now on market.

The Nile perch was previously the main source of filleted fish on the local market. Because it was cheap, most consumers purchased Nile perch fillet for their children. However, it is mostly the Nile perch that is exported as fillet out of the country and alternatives have to be sought. Farmed
catfish fillets are now beginning to find their way into the local market where they offer a good substitute. In addition, catches of the *Bagrus dogmac* (Ssemutundu), a delicacy in Buganda, have declined so much that one hardly finds these fish in the local markets anymore. More people are now buying the high quality smoked catfish from farms as an alternative. This African catfish is also a delicacy in the Eastern and Northern parts of the country. Consequently, by 2007/2008, about 33 tonnes of catfish were sold from 20 farms that reported to the USAID FISH Project. The forms in which table catfish is sold are:

1. Whole fresh catfish
2. Whole smoked catfish (*gutted*)
3. Catfish frozen fillets
4. Catfish smoked fillets

### 1.5. Are You a Commercial Farmer or Intend to be One?

In order to classify oneself as a commercial fish farmer, one must undertake to do the following:

**Table 1.1: Characteristics of a Commercial Fish Farmer**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Plans production around targeted markets.</td>
<td>• Production without any strategy.</td>
</tr>
<tr>
<td>• Employs technically-trained and knowledgeable personnel.</td>
<td>• Source of employment for friends and relatives.</td>
</tr>
<tr>
<td>• Management approach is performance oriented - yields, productivity (efficiency of production) and profits.</td>
<td>• Management approach simply to keep fish, not bothered about yields or profit as long as units are full of fish.</td>
</tr>
<tr>
<td>• Harvests and sells fish based upon a plan.</td>
<td>• Irregular harvesting and sales of fish.</td>
</tr>
<tr>
<td>• Produces for profit.</td>
<td>• Not bothered about returns or length of production cycle.</td>
</tr>
<tr>
<td>• Costs all inputs inclusive of own labor.</td>
<td>• Does not cost all inputs especially labor.</td>
</tr>
<tr>
<td>• Keeps and analyses written records of production, costs and returns.</td>
<td>• Does not keep any written records.</td>
</tr>
<tr>
<td>• Information from farm’s records form the basis for making management decisions. The farm’s records are the key management tool.</td>
<td>• Information from records, even if kept, are not analyzed nor used to improve efficiency of the farm’s management and operations.</td>
</tr>
</tbody>
</table>
Plate 1.1: Nile Perch Frames
Nile perch frames have increasingly taken more of the retail market share in city suburbs and upcountry due to the reduced supply of affordable whole fish to these markets. They would be your main “competition” if your farm is in a rural area.

Can you produce a better product at an affordable price and still make a profit? This manual can show you how.
a. Whole Catfish, also sold live at live fish markets.

b. Smoked Filleted Catfish.  

c. Whole Smoked Catfish.

d. Frozen Catfish Fillets sold at supermarket.

e. Restaurants can be convinced to carry catfish dishes. Ask for catfish masala at Faze 2 in Kampala.

Plate 1.2: Products from Farmed Catfish Available in the Ugandan Market
CHAPTER 2:

MARKETS AND MARKETING

The market is the driving force for commercial aquaculture. Before deciding to invest into aquaculture, one must have identified a potential market to which the fish produced can be sold profitably. This is because the market influences the farm-gate price of the fish produced, what quantities one is able to sell at a time and how frequently sales can be done. Consequently, it is the target market that determines the levels of one's investment in aquaculture, the species to grow, size of harvest and even the size of pond. Therefore, the optimum size of one's operation, the technology one should adopt as well as what production management strategy the farmer should have is based upon the market they wish to enter.

The detail to which specific activities in the enterprise are undertaken is additionally governed by the physical and financial resources the farmer has at hand. For example, if a farmer has an acre of land and is to supply $x$ amount of catfish per week to the market, the following are among the decisions the farmer would have to make:

1. How many ponds should I have in order to meet my market targets?
2. What size should the pond(s) be?
3. How many of these ponds can actually fit on my land?
4. How long should my production cycle be?
5. What kind of management should I adopt for timely harvest?
6. What would be the optimum size of fish to produce?
7. Should I co-opt other farmers with whom I can work collectively in order to meet the demand of the identified market and maintain it?

2.1. Identifying the Market and its Needs

Enquiries need to be made to identify the potential customers and traders. However, one should bear in mind that it is very easy for someone to respond, "Yes, if a product is available I would be interested in purchasing certain amount so many times per week or per month".

The best way to ascertain the market after an initial survey is to test it by actually selling the proposed product. If you do not have fish to do this, buy some fish from another farmer and sell it to the proposed market. In this way you will be able to interact with your would-be
customers more directly and observe who is actually coming to buy fish and why. You can also gauge the prices the market can offer, people’s opinions on the product, as well as their views and perceptions on the fish you have brought for sale. This is less costly than constructing your own fish farm only to discover you cannot get the price you thought for your fish.

After obtaining this information, one is in a better position to assess the size and preferences of the market in question as well as work out what marketing strategy would be best for penetrating, expanding or sustaining the market. Potential lenders or co-investors appreciate this type of practical research much more.

2.2. Know your Product
It is important to know exactly what product your customers will want because that is what you shall sell. Know the species they desire, what size they want and whether they would prefer it whole, fresh, filleted or smoked. All these factors define and encompass the quality of the product to be produced. Knowledge of the qualities of your product also give you advantage while marketing your product.

For example, if you would like to supply restaurants, as a fish farmer you should be in position to supply a uniform size of fish as specified by the customer as opposed to someone who sources their fish from the lake. A fish farmer can guarantee freshness because only farmed fish can be supplied alive to the customer. There is no fish fresher than one supplied live (see appendix 1 for criteria used to grade fish). Hence, the farmer can negotiate a better price. It is for among these reasons, that the processing plants are increasingly preferring to source farmed fish.

If you are supplying an intermediary, the quality requirements of the final market will be passed on to the producer because quality control starts at the point of production. Hence, the fish processors exporting catfish fillets prefer receiving the fish live because it enables them meet the fillet quality criteria their markets want. Also farmers intending to produce for organic markets are restricted not just from the general use of chemicals but also on what sort of ingredients are contained in the feed. Furthermore, a farmer who keeps the recommended records is able to show traceability in the production process which is a vital factor in quality assurance which gives advantage in penetrating certain markets, notably processing plants, restaurants and supermarkets.
Fish farmed and handled for market following Best Management Practice can be guaranteed as being of a superior quality (See appendix 1 for criteria used to grade fish quality based on physical characteristics).

2.3. Choice of Management Plan

The choice of what management plan and production technology would be most appropriate is best made after identifying the market and its needs. The production plan you adopt should enable you produce the desired quantity and quality at the frequency the market demands.

For example, does the market require you to supply $x$ kg of fish product $y$ daily, weekly, or monthly. One must be in position to produce the required product at a cost lower than the price the market can afford to pay so that a profit is made. The management practices you employ also affect the quality of your product and the price you can sell it at. For example the type of feed you use affects the fish quality; fat content, taste, etc (See Plate 2.1 for a picture of catfish fillets – fatty fish versus a lean fillet).

The choice of technology, location and management are therefore linked to your market's needs as they determine what levels of production are achievable as well as the efficiency and costs of production. For example, choice of location affects one's production and returns in the following ways:

1. The location determines what physical resources (such as soils, water quality, land) are available for production and the cost at which they are available for production. Therefore, if the farm is close to the city, the unit cost of land is likely to be high and it will probably be too expensive if one wanted to increase production by increasing the number or sizes of one's ponds. It would be more viable in such a case to increase production by increasing the carrying capacity of the existing units (see Chapter 4 for more details).

2. When a farm is small, smaller amounts of fish are likely to be produced. Therefore, small farms need to get higher profit margins if their establishments are to be economically viable. Such farmers would therefore, rather directly retail to niche markets who can offer a higher price.
3. Farms located in remote areas where land is cheap, water and, labour are easily accessible at lower costs can afford to have large production units and produce for the bulk markets. Such farms can afford to opt to supply bulk markets at a lower profit margin because they have the capacity to produce large volumes and have a high turnover. Adopting lower levels of technology in such a case may be feasible. However, transport costs for inputs and for marketing fish can have quite an impact on profit.

See chapter 10 for an example on how one can tailor one's production program to specified market requirements.

2.4. Siting the Farm

When siting the farm, the following are among the major considerations one should take into account:

1. **Availability of suitable land** with a reliable source of water and good climatic history e.g. no floods.

2. **Accessibility to the Site** for supply of inputs and for taking produce to the market. Accessibility and distances from one's sources of inputs as well as to the market affect transporting costs. Being close to the market and sources of supply reduces transport costs and can make a difference on profit margins.

3. **Market availability and accessibility.** If one is retailing directly from the farm for example, it is much better to have the farm located as close to the market as possible. If, on the other hand, one intends to do bulk sales every so often, then the farm can be further away from the market as you would be transporting and delivering large amounts to one destination probably once a week or month. Also bear in mind that fish is a highly perishable commodity when fresh. If one is to supply fresh fish and does not have facilities for live transportation or holding fish alive - invest in this equipment. If the market requires smoked products, the farm would take into account easy access to the correct type of firewood and ability to process and smoke large amounts of fish in that environment.

4. **Other land uses in the vicinity.** All fish farmers should take note of what sort of activities go on in their surroundings because of their
potential impact on your production and product quality. Care should especially be given to activities that are likely to affect on the quality and volume of water to the farm. For example, it is not recommended to site a fish farm where the effluent from factories enters your water source, as most probably the effluent is likely to have a negative effect on the quality of water for fish production.

5. **Utilities.** Does the production technology you intend to adopt (e.g. for storage of fish) require that you need power? If it does, then the farm should be in a location easily accessible to power.

6. **Roads and other Transport Networks.** These influence accessibility and costs of getting to the farm.

7. **Social Aspects.** For example, it would not be wise to set-up a commercial smokery in the middle of a residential area as your neighbors might complain.

### 2.5. Profit Margins in Grow-Out Fish Farming

There is a limit on what the maximum price one is likely to get from a fish of a given size/weight depending on its perceived value by the market. This is because the customer can easily opt for other alternative sources of protein such as eggs, meat or milk if they find fish too expensive.

Generally the profit margins obtained from farming fish in Uganda range from 10% to 30% of operational (variable) costs. This means that cost of land and ponds has not yet been taken into account. The profit margin though, may be higher or lower depending on one’s local markets and specific marketing strategy. It is not just the growth rates achieved that matter for profitable production, but also survival rates, feed conversion and total yield. What this tells an investor, though, is that if all investment is to be covered by a loan, the entire profit is likely to be used as interest payments, given that interest rates are often above 20% in Uganda. Most people do not wish to be merely "working for the bank".
2.5.1. Adding value

The other way of increasing profit margins and income from table fish production is to add value to the product. For catfish, locally this can be done by smoking and or filleting the fish (see Chapter 7.3.4. for more details). However, before deciding upon value addition, calculate the returns based on “live weight equivalent” (See example in Box 1 below).

Box 1: Example of How to Estimate Returns Obtained based on “Live Weight Equivalent”

A farmer sells a piece of catfish that has been gutted and smoked at USh. 10,000/= per kg. What is price the farmer is getting for the each unit weight of fish before processing?

One requires 4 kg of fresh (whole) catfish to produce 1 kg of smoked catfish. Therefore, if a farmer decides to sell a kilogram of smoked catfish at USh. 10,000/= per kg, then the value of 1 kg of fresh catfish = 10,000/4 = 2,500 USh

The farmer is actually getting USh. 2,500/= per kg live weight of fish produced.

Note that labour and supplies are required to turn this into a smoked product. So the cost of production is higher as well.
2.6. Sustaining the Market

As a producer, it is in your interest not just to be able to produce and sell fish once, but to continue to sell whatever you produce at a profit. This is because the investment one makes to establish a fish farm is large and the cost will have to be paid off with time from the products sold.

One of the surest ways of keeping and building up your market is through CONSISTENCY in supply and quality. The farmer (or group of farmers) should be in a position to guarantee consistent supply and product quality based on the market requirements.

The market’s needs therefore determine the ideal place to site a farm, the farms’ set-up and production plan (see Chapter 10 for more details). When seeking advice on planning your farm, a good advisor should ask the following key questions:

i. What your target market is?
ii. What product does the target market want?
iii. What quantity do you want to produce?
iv. At what frequency would you like to produce specified amounts?

The advisor should then ask you to explain how you came to these decisions and what resources you have at your disposal for producing the fish. Based on your answer, the advisor should be in position to let you know:

(i) whether or not you can achieve your production objectives,
(ii) what your management options are,
(iii) the viability of the enterprise as well as what challenges you might face.

And finally, you would decide whether or not you should invest in fish farming. Remember, if you aren’t sure, starting small means you can only make small mistakes. Making mistakes when you start big can be very costly.
a. Lean Catfish Fillets, with the belly flap or “nugget”

b. Feeding catfish with feed high in energy or rich in fats results in the deposition of a lot of fat within the flesh. Sometimes the fillets can be unmarketable.

Plate 2.1: Flesh Quality
A commercial fish pond is one of the several production units used in fish farming. A pond must be able to hold water and sustain favourable conditions for production. One should also be able to undertake the required pond management activities (such as harvesting and feeding) effectively, with relative ease and safety. The physical attributes of a pond, therefore, have a direct influence on achievable levels of production and returns.

Consequently, poorly constructed ponds, give poorer production yields and returns. This is because additional management efforts and associated costs are required to achieve comparable yields. Paying attention to pond design and construction detail is, therefore, the first step to successful pond production.

### 3.1. Recommended Pond Construction Criteria

Recommended pond standards are discussed below in relation to management and production potential.

#### 3.1.1. Pond Levees (Dykes)

The pond’s sides are called levees or dykes. The pond levees should be well compacted and have a gentle slope (see section 2.1.2 below for slopes). The greater the degree of compaction, the stronger the levees will be. Thus, during construction, one should lay down about 15 cm of soil which, when compacted will become about 10 cm high. There should be no stumps or debris left within the pond levees. Soil should be compacted shortly after it is laid to prevent hardening (some soils become rock-like if they are allowed to harden).

The level of compaction achieved when constructing the pond levees affects pond management and production as follows:

a. Poorly compacted levees are weaker and often collapse during the course of production when wind pushes the water and causes waves to wash against the levees thus eroding them. When pond levees collapse during the course of production:
Chapter 3 – Pond Requirements and Pond Preparation

- The ponds become shallower which lowers the ponds' carrying capacity (See Chapter 5 for more details on carrying capacity).
- There is increased siltation and clay turbidity which have a negative effect on water quality for production.
- Mud at the pond bottom can become excessive which makes it more difficult to harvest ponds. It is a double tragedy if the collapsed levee also contained a lot of organic matter and not just soil because the organic loading in the pond will rise. High organic loads reduce dissolved oxygen and pH (see Chapter 4 for more details).

b. Increased Maintenance Costs. Pond construction is expensive. The life-time of a properly constructed pond should be at least ten years with minimum maintenance. Poorly constructed levees have to be re-constructed and the bottoms of such ponds will also have to be de-silted in between each cycle if meaningful yields are to be obtained. This is costly. It is therefore, cheaper in the long run to have the levees constructed correctly from the start.

c. Catfish, by nature, are bottom-dwellers. They tend to dig into the levees of ponds and create what is termed the 'catfish highway'. The degree to which they are able to do so is affected by the amount of compaction of the pond levee and its slope. In addition to increased levels of siltation, deep catfish highways make harvesting with a seine less efficient as the fish have a hiding place and can circulate around the pond sides, thus avoiding the seine. Predators also take refuge in such places.

d. Control of Water Volumes and Quality. Proper compaction reduces the rate of seepage across the pond levees. The only source of water loss from a properly constructed pond should be from evaporation. When the levees are properly compacted:
- One has better control over the water volume during the course of production. Significant falls in water volume result in reduced pond carrying capacity because there is less water to dilute wastes, such as ammonia, which is stressful to the fish. In addition, fish in shallow ponds are more subject to predation by wading birds such as the marabou stork. Consequently, feed performance, growth and survival rates fall.
• Significantly much less water is used per production cycle as the only water that needs to be added is to top up for evaporation. This has cost implications especially in a situation where a farmer has to pump water into the pond. Saving water is also environmentally friendly and can limit water use conflicts.

When the levees are poorly compacted:
• Ponds are leaky (constantly losing water) and, therefore, one has to frequently keep adding water to maintain the water levels. This makes it difficult to effectively adopt the 'Static Water Pond Management' technique which enables the farmer to have more control over the water quality parameters in the pond. Leaky ponds are also risky because during dry seasons, adequate water for replacement may not be available.
• Such a pond needs constant refilling - cold water will always be entering the pond and acidity levels could be higher. Production from such a pond will be reduced. This is because warm, neutral pH water with oxygen levels nearing saturation is best for fish growth (see Chapter 4 for more details).

e. Debris, such as tree stumps, sand bags or rock outcrops, left in the pond levees or at the bottom of the pond during construction reduce compaction and decay over time. When these obstacles protrude from the levees or pond bottom, they tear nets during seining and often injure the persons working in the pond. In addition, they become weak points through which water starts seeping. As time progress, the action of water results into creates actual holes being created from such weak points. Water is then continuously lost from the pond. Fish also escape from ponds through such points. Predators also use the obstacles or holes, as refuge or entry-points into the pond. Dissolved oxygen is also used up by rotting organic material. As tree stumps and other organic matter left in the pond levees starts to rot, levels of dissolved oxygen are depleted faster in the pond. Low dissolved oxygen levels result in poor fish growth.

f. Erosion into ponds increases the levels of clay turbidity and pond siltation. Production will then fall as has been explained in section 3.1.1.-a above. Therefore, it is important to plant grass over the
top-width down to the water level to prevent soil erosion into the pond.

### 3.1.2. The Slope of the Pond Levee

The slope of the pond *levee*, is the gradient of the *levee* from the edge of the top width to the inside *toe* at the bottom of the pond. It is described as the ratio between the horizontal distance and the vertical height of the dam *levee*. This means, for example, that if the distance from the inside *toe* to where the top width starts (edge of the pond from above) measures 2 meters and the height of the dam measures 1 meter, then the slope for that *levee* is 2:1 (see figure 3.1 below).

**Figure 3.1**: Parts of the Pond Levee. In this example the *levee* is only 1 m high but it is usually higher at the deep end.

It is recommended that pond *levees* have a gentle slope of about 2:1. This however, depends on the size of the pond. Larger ponds need to have a gentler slope (see table 3.1 below).

#### Table 3.1: Recommended Slopes for Production Ponds

<table>
<thead>
<tr>
<th>Size of Pond</th>
<th>Recommended Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 20 ha</td>
<td>4:1 to 7:1</td>
</tr>
<tr>
<td>1500 m$^2$ to 5,000 m$^2$</td>
<td>2:1 to 4:1</td>
</tr>
<tr>
<td>+ 150 m$^2$ to 1,500 m$^2$</td>
<td>2:1</td>
</tr>
<tr>
<td>≤ 150 m$^2$</td>
<td>1.5:1 to 1:1</td>
</tr>
</tbody>
</table>

**NB**: Remember, the larger the pond, the gentler the slope should be. Large ponds have a greater surface area to perimeter ratio. This makes it possible to obtain the greater amounts of earth needed to make gentler slopes from within the pond during construction.
Having a gentle slope is beneficial in that:

a. A gentle slope helps break up the waves as they hit upon the pond levee. This reduces the impact of the water waves on the levee. Consequently, the levee is less likely to collapse and there is less siltation of the pond (see figure 3.2). The lifespan of the pond is also subsequently increased and maintenance costs are lower. Better yields (in as far as the pond infrastructure is concerned) can therefore be sustained beyond one cycle. The ability of catfish to make a deep ‘catfish highway’ will also be minimized.

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**How a Pond Levee becomes Eroded Away**

The levee gets eroded mostly at the waterline and "undercut banks" are created, which then collapse as shown below.

**BEFORE**

- Poorly sloped usually with a high free board

**AFTER**

- An "Undercut" bank about to collapse. The "silt" in the pond bottom is actually the soil that eroded form the levee.

---

A properly constructed levee with the right slope and freeboard get less impact from wave action.

**BEFORE**

**AFTER**

---

**Figure 3.2**: How a Gentle Slope Reduces the Impact of Waves on a Pond Levee.
b. It is easier and safer to enter into and out of the pond to undertake activities such as seining. One should be able to actually walk into and out of a pond and **not** have to ‘jump in and climb out’ of the pond. The latter is dangerous for personnel.
c. It makes it easier to seine the pond and land the seine.

Significant environmental benefits are derived when pond *levees* are constructed as recommended with the appropriate slopes. There is less pond siltation when *levees* are constructed as recommended. Consequently, there is also a reduction in the level of suspended solids in pond effluent water. In addition, less water is required for production due to reduced seepage.

### 3.1.3. Average Water Depth

The recommended average water depth is 1 meter for non-aerated *static water* ponds (Schmittou et al., 1998). The water depth in the pond should be at least 80 cm at the inlet and no more than 1.2 m at the outlet.

**The Maximum Water Depth** for *static water* pond production is determined by the distance sunlight can penetrate into the water column. This is because photosynthesis can occur in the water column up to twice the depth the sun’s rays can penetrate. In ponds, sunlight can generally penetrate to a depth of about 30-80 cm depending on the levels of water *turbidity*. Photosynthesis can occur up to a depth of twice that of sunlight penetration. The oxygen generated during the process of photosynthesis then dissolves into this section of the water. In addition, the sun’s rays warm up the water. Hence, the upper water column in ponds has the best conditions for fish production (see figure 3.3 below).

![Figure 3.3: Water Quality Dynamics in a Pond](image)

### Figure 3.3: Water Quality Dynamics in a Pond

- **Sunlight penetration in H₂O to 35 cm**
- **Waters below a depth of 1.2 m colder and devoid of oxygen**
- **Properly compacted and sloped levees prevent seepage and collapse of pond walls**
- **Freeboard 20 to 50 cm depending on size of pond**
- **Oxygen in water to max depth of 1.2 meters**
- **Wind action**
For this reason, a maximum water depth of 1.2 m is recommended. Beyond this depth, pond waters start becoming devoid of oxygen and stay cooler. Ponds thermally stratify from about 1.2 m water depth downwards. This means that the temperature and quality of the top 1.2 m of water will be distinctly different from that of the water below 1.2 meters deep. When the pond is deeper than 2 meters, the total volume of bottom zero-oxygen water is greater than that of the water containing oxygen. Incidences of fish kills consequently, become more likely when there is a change in weather (for example when it rains, it is windy, it becomes cold, etc). This is because, the cool rain causes the oxygen rich water at the surface to go down and in the process, the oxygen-deficient water from the bottom is pushed up. The mixing of the oxygen-deficient water from the bottom with the rest of the pond water results into an overall total oxygen depletion. When this happens, the farmer observes that fish which showed no signs of stress the previous day, or a few hours ago, are suddenly all dead and floating on top of the pond. Even though catfish above 100 g can survive water deficient in oxygen for a while by breathing atmospheric air, there is also the additional risk of the mixing of hydrogen sulfide and other toxic chemicals that may be present in the deep, zero-oxygen layer. Hydrogen sulphide is lethal to fish, even in extremely small amounts. See chapter 5 for more details on water quality requirements for catfish production.

Therefore, there is no added advantage in having a pond with a water depth greater than 1.2 m. The deeper the pond is, the more expensive it is to construct, and the riskier it becomes to manage water quality because stratification becomes more likely - unless one has equipment to mechanically mix and aerate the water. Such equipment is expensive and requires a reliable source of power. In addition, for the current farm-gate price offered for table sized catfish in Uganda, it does not yet make economic sense to invest in mechanical aerators for grow-out ponds.

**The Minimum Water Depth** in a pond should be not less than 60 cm. When the pond water depth is less than 60 cm:
  a. The pond’s *carrying capacity* is reduced considerably (see figure 3.4 below). For catfish ponds, the total water volume is very important because the water dilutes the catfish wastes. Because catfish can breathe air after they have surpassed the *fingerling* stage (i.e. from +100g), waste build-up becomes the first limiting factor. Shallow ponds have less water volume than deep ponds and
therefore have a lower carrying capacity. This means fewer kilograms of fish can be harvested from the same pond area. Having the recommended depth therefore, increases potential to harvest more kilograms of fish from the same pond, making it more productive.

Figure 3.4: An Example of the Effect of Pond Depth on Fish Yields. Data from Ponds at ARDC - Kajjansi stocked with tilapia. The ponds were at carrying capacity when harvested.

Figure 3.4 shows that the deeper the pond, the greater the ponds carrying capacity. This implies that more and/or larger fish can be produced from a given pond area depending on the water depth - up to a point. The graph indicates that a farmer whose pond is about 55-cm deep can expect to harvest 64% of what a farmer whose depth is about 80 cm - 1.00m harvests. For catfish in static water ponds fed commercial pellets, the pond carrying capacity is 18 to 20 tons/ha when average pond depth was 90cm. Carrying capacity was reached at 12T/ha when catfish ponds were 60 cm deep.

b. It is easy for wading birds, such as the marabou stork and heron to enter the pond, scare predate upon the fish. Such birds can only enter ponds they can step down in (see Plate 3.1).

c. Aquatic weeds are more likely to grow in shallow ponds (see Plate 3.2). Excess weeds in the pond interfere with seining and reduce the levels of dissolved oxygen available for fish production.
Consequently, FCRs are likely to increase and pond yields to decline (see Chapter 5 for more details).

3.1.4. The Inlet and Outlet
The diameter of the inlet pipe should be less than that of the outlet pipe in order to prevent overflow from the pond in the event that someone accidentally leaves the inlet open.

The inlet pipe should be at least 20cm above the water surface to prevent fish from escaping. If the inlet is set at or near the level of the water, fish will swim against the current of the inflowing water and escape from the pond (see plate 3.3). When the inlet is above the water level and properly screened, fish are unable to jump into the pipe and escape through the inlet pipe. The screen also prevents fish outside from the pond entering it. Avoid open earthen channels as inlets to commercial ponds. Such channels are difficult to screen effectively and often erode, thus becoming closer to the pond water level each year. Clarias catfish are more likely to escape from the pond through the inlet as opposed to climbing out of it on the pond sides. They also escape when the pond overflows totally due to a blocked standpipe, during heavy rains.

Old literature recommends that the pond inlet and outlet be located at opposite ends of the pond to facilitate flushing (good water in and poor water out) when poor water quality becomes an issue. However, this is not all that important if you flush the recommended way (see chapter 5).

Pond outlets should have an anti-seep collar and an anchor-collar. The anti-seep collar prevents water seepage from the 'joint' where the outlet pipe and clay soil meet. These two substances do not bond together and water tends to follow the outside of the pipe unless interrupted by an anti-seep collar. Anti-seep collars are standard construction principles but have been ignored in most pond construction and most ponds have leaks as a result.

When not in use, the drain pipe is full of air, which makes the pipe tend to float. If the PVC pipe is not secured at the pond bottom, the pipe can be dislodged at the bend or leaks can develop due to the pipe floating up slightly. (Plate 3.4). Having an anchor-collar just after the pipe bend prevents this by keeping the drain pipe and its bend down.
3.1.5. The Free-Board Height

The recommended freeboard height is 20 to 30cm for the following reasons:

a. It allows for more free movement of air currents above the pond water surface which improves mixing and oxygenation of the water.
b. It becomes easy to undertake routine tasks such as feeding, seining, checking water quality and removing dead fish.
c. It is cheaper to construct and maintain.
d. There is less surface area for erosion into the pond. Therefore, this contributes less eroded silt to the pond water and soil.

However in ponds of over one hectare a freeboard of up to 50cm can be accommodated (table 3.2).

Table 3.2: Recommended Free-Board Heights for catfish grow-out ponds

<table>
<thead>
<tr>
<th>Pond Size Range</th>
<th>Freeboard Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Smaller ponds (100 m² up to 1 ha)</td>
<td>• 20 to 30 cm freeboard is sufficient.</td>
</tr>
<tr>
<td>• Large ponds (&gt;1ha)</td>
<td>• 50 cm is recommended because there can large be waves on the pond.</td>
</tr>
</tbody>
</table>

It is undesirable to have a free-board higher than what is recommended because:

a. It is an unnecessary added construction cost - expensive to make.
b. It attracts predators and burrowing animals such as nutria and muskrats. Plate 3.5 shows a picture of kingfisher nests in a high freeboard.
c. High freeboards above the water favor the nesting flying ants and termites, which later leads to leaks.
d. It makes working on the pond difficult and dangerous.
e. A high freeboard prevents air currents from reaching water surface, thereby preventing mixing and reducing oxygen exchange.
f. Looks ridiculous.

3.1.6. The Pond Bottom and Ability to Drain

The pond bottom should be smooth and firm. Pot-holes at the bottom provide shelter for fish to hide after ponds have been drained. Such fish, if not removed, will predate upon the new stock. Survival rates for the new cycle will subsequently be lower with a few very large shooters. The pot-holes also pose a danger to persons seining the pond who may trip and injure themselves. If the bottom is not firm, fish can hide in the
mud. Thick layers of pond bottom mud not only have a negative effect on pond productivity, but are also more difficult to seine. At drainage, a lot of fish also get trapped within the mud. Sampling and harvesting is therefore, more difficult and time-consuming in such ponds.

It should be possible to completely drain and dry the pond bottom, after harvests and between cycles. This helps to ensure that all fish have been harvested. Being able to drain ponds completely in between cycles makes it easier to undertake routine treatments and required maintenance work with better results. Preferably, ponds should be able to fill and drain completely by gravity to avoid pumping water, which is costly. Therefore, a pond bottom slope of 1-2% to the outlet is recommended. Ponds and drainage canals should also be constructed above the water table. Ponds constructed below or at the level of the water table, are impossible to drain and dry completely. In addition, yields and returns from such ponds are poorer, because of the constant infiltration of cold, non-oxygenated sometimes acid water from the water table into the pond during the course of production. Consequently, the quality of water within the pond becomes less suitable for production.

NOTE: All it takes is one catfish left in the mud, and the next round of fingerlings stocked in the pond after re-filling will be eaten by the remaining large catfish. The survival rate of the following cycle will be extremely low.

3.1.7. Harvest Basins
Having a harvest basin set in the pond or between ponds is optional but recommended. Harvest basins make it possible to hold and handle fish alive while draining ponds. They also reduce the amount of labour required during complete pond harvests. A harvest basin can either be set within or outside the pond. Plate 3.6 shows pictures of a harvest basin set in a pond and outside the pond respectively. Ponds that are to be drained frequently, for example nursery ponds, are much easier to harvest if they have a properly constructed harvest basin.

3.1.8. Shape of Pond
Typically, ponds are rectangular. Rectangular ponds are more practical to construct, feed and manage. The narrower pond dimension dictates the size of the seine that will be needed. Therefore, if one has ponds of several sizes on the farm, it is a good idea to have them of similar widths, if possible so that the same seine can be used for all ponds.
3.1.9. **Accessibility**
All ponds on the farm should be easily accessible for adding inputs and transporting harvested fish from the pond with relative ease and safety.

3.2. **Pond Preparation**
Pond preparation for *stocking* marks the beginning of the ‘grow-out’ *production cycle*. Before the pond is *stocked* for production, it should be prepared in the following way:

3.2.1. **Remove Excessive Silt from Pond Bottom**
The bottom of the pond bottom should be free of excessive amounts of silt. It should also be dry and firm before filling. Silt removed should **NOT** be put at the top of the pond *levee* (as this will increase the free board), but rather away from the ponds and/or used to repair the pond *levee* slopes. **Remember**, much of the bottom “silt” came from the slopes of the *levees*. It should, therefore, be put back from where it came. If the soil is heaped on top of the dykes, it will wash back into the pond when it rains. Because the bottom silt often contains high levels of nutrients, e.g. from leftover feed (if the person is a bad feeder) and faeces, it is sometimes used to fertilise vegetable gardens. However, unless the feed input was excessive, the amount of nutrients in the silt is often not enough to justify the labour that is required to move the silt to a garden.

When soil builds up on the bottom of the pond, the pond becomes shallower. **Over time**, the bottom mud becomes increasingly anoxic (no oxygen), forming hydrogen sulphide which lowers water quality for production. This is of particular problem when a farmer overfeeds the fish, which can often occur when sinking feed is being used. After several seasons of mud build-up in the pond, the pond’s yield and *carrying capacity* for the new cycle will, therefore, be lower than that of the previous cycles.

If there is not so much silt, the bottom can be left to dry until the surface cracks slightly before the pond is re-filled with water for the next cycle (see **Plate 3.8a**). The cracks allow air to enter between the mud and *aerate* it. Alternatively, the soil can be disked to aerate and increase the rate of decay of organic matter which in turn, reduces the rate of formation of substances such as hydrogen sulphide.
3.2.2. Ensure the Pond is not leaking

Repair all broken dam levees and make sure there is no seepage through the pond levees or around inlets or outlets for the reasons already discussed in section 3.1 above.

3.2.3. Screen the Inlet and Outlet

The objective of screening, is to prevent undesirable substances (fish and fish eggs, inclusive) from entering or leaving the pond without obstructing the flow of water. Therefore, the mesh size of the screen material should be small enough to prevent un-wanted substances passing through, while at the same time be large enough to allow water to flow through. However, the efficiency with which the screen works, is not solely determined by the mesh size of the screening material. It is largely determined by the total surface area of the screen and the rate at which clogging occurs.

3.2.3.1. Screening the Inlet

It is therefore, recommended that inlets be screened using a 'filter sock' made of fine mesh (see Plate 3.7a). Figure 3.5 shows and explains how a filter sock should be fixed over the inlet pipe. In this way, a large surface area is provided and the rate of clogging significantly reduced because the debris collects at the tip of the sock. In this case, water will still flow un-obstructed from the top of the sock. Remember, it is not practical or possible to check the screen every hour and clean it. Screens tied flat tend to clog fast and do not allow water to flow through within a short period.
How to Screen an Inlet

What do I need to for screening an inlet?

1. 2 long rubber bands of about 1.0 to 1.5mm thick.
2. Screening material which can be made of several materials e.g. old gunny bag, shade cloth, mosquito net, fire hose casing, etc.
3. Sew this material into the form of a sock i.e. only open at one end or purchase as tubing and tie a knot in one end.

A. Tie a long rubber band made out of an old tyre tube around the pipe until you get a bump.

B. Pull the sock over the pipe beyond where the rubber band is tied.

C. Clasp the sock with your hand after the bump and tie the sock now with another rubber band. Tie this one behind the first one as shown.

D. Fold the extra flap over the second rubber band as shown and finish.

Tying your screening sock as illustrated above prevents it from being pushed off the inlet pipe by the inflowing water.

**Figure 3.5**: How to Screen the Inlet Pipe.
3.2.3.2. Screening the Outlet

The outlet stand pipe, on the other hand, is best screened with cone mesh (see Plate 3.7b). Figure 3.6 shows how a cone mesh should be fixed over the outlet pipe. Again, this increases the total screen surface area to ensure water can flow out with minimal clogging. Ensuring the outlet screen is in place prevents loss of feed during feeding and of fish during drainage.

What do I need to for screening an outlet?

1. Wire mesh
2. Bits of string or wire to tie mesh as a cone.

A. Cut out a piece of coffee mesh of about 0.5m (get measurement of the square)
B. Roll it into a cone similar to those made for roasted groundnuts. But open up the tip
C. Fix the cone into the standing pipe as shown above. The screen is kept in place by out-flowing water.

Figure 3.6: How to Screen the Outlet Pipe.

Keeping the water level slightly below the top of the standpipe allows one to collect rain water and prevents unintentional outflow of fertile water during heavy rainfall.
The stand pipe should be cut to the maximum height you would like to have water in the pond. Doing so prevents flooding beyond the levee wall, because the pond will start draining once it gets to the desired water height. However, for practical reasons, during the course of production it is best to maintain the water level at about 10cm below the standpipe height. This is to act as a buffer in the event that it rains as it allows the pond room to capture rainwater.

3.2.3.3. Maintenance of Screens during the Course of Production

It is important to check all screens daily to ensure they are not clogged nor damaged. If there is a lot of debris, remove it and clean off the dirt by shaking and rinsing the screen. Do not shake the screen into the pond as the debris will only go back into the pond and re-clog the screen. Place the screen back immediately after cleaning. If damaged, repair or replace screens immediately. Damaged screens are an urgent matter. If you find fish or frogs in the screen, bury them as they are likely to find their way back into the ponds which is undesirable.

3.2.4. Fertilizing the Pond

There is no need to fertilise ponds for catfish grow-out if the fish are fed on nutritionally-complete pellets. This is because all their food requirements are derived from the feed. Catfish grow-out monoculture ponds fed nutritionally complete pellets only need to be limed if:

a. The pond soils are acidic, pH 5 and below. In this case, lime with agricultural lime, preferably in the fine powder form by spreading uniformly over the pond bottom or pond (see Plate 3.8b).

b. The pond cannot drain completely. In this case, lime the remaining puddles with builders lime (Ca(OH)₂) or quick lime (CaO) until the water pH increases to 11. The objective of attaining such a high pH in this case is to kill off any fish, frogs, potential diseases or parasites that might remain within the pond. Spread the lime over the pond bottom while paying extra attention to potential hiding places. This is necessary because any catfish left in a pond from a previous cycle can easily literally predate on all the new stock.

After liming, the pond can be filled with water the following day but only stock it when the pH has decreased to below 8.
3.2.5. Filling the Pond

Fill the pond with water after properly screening the inlet and stock it within 7 to 10 days of filling. However, ALWAYS check that the water quality is suitable for fish production before stocking, especially if treatments have been applied to the pond. If no water quality test kit is available, place a few catfish in some netting material for a couple of days before the intended stock date. If the fish do not die, then most probably the pond water quality is good enough. The pond can then be stocked. If the fish die, wait for a couple of days and try again.

Stocking the pond as soon as possible after it has been filled, gives the stocked fish a head start before other animals, such as frogs and predatory insects establish themselves. Frogs can tell when fish are in a pond. Frogs search for ponds with water but no fish to lay their eggs. When unwanted animals become established in ponds, they:

(i) can predate upon the fingerlings,

(ii) consume some of the fish feed, and

(iii) compete for dissolved oxygen.

This results in reduced fish survival, increased FCRs, and a slight reduction in carrying capacity due to competition. Consequently, depending on the severity, yields obtained are lower than would be expected. A pond full of tadpoles is especially disastrous if you are going to stock very young catfish fry.

3.2.6. Pond Record Keeping

Document all details of pond management and treatments, as well as any other observations associated with pond preparation, in the pond’s record sheet. See Chapter 9 for more details and figure 9.2 for an example of a properly filled pond management record sheet.
Summary Guidelines for Pond Construction and Preparation for Stocking

The pond is the foundation for success in pond fish production. It directly affects pond yields and returns because of its influence on the following:

1. The pond carrying capacity,
2. Water quality and water volume control in the pond,
3. The number of fish that survive to harvest.

A] Recommended Standards for Commercial Grow-Out Ponds

1. The pond levees must be well compacted with a slope of at least 2:1.
2. There should be no debris, such as tree stumps, within the pond levees.
3. Average water depth in a pond should be 1 meter (0.8m at shallow end to 1.2m at the deep end).
4. Inlet pipe at least 20cm above the pond water level and screened with a properly fitted sock.
5. Outlet pipe fitted with collar and screened correctly with cone mesh.
6. Freeboard of about 30 to 50cm depending on size of pond and its levees planted with grass are recommended.
7. Having a harvest basin is optional but is highly recommended.
8. The pond should be able to drain completely. The pond bottom should be firm, without ‘pot-holes’ and gently sloped (1 to 2%) from the inlet to outlet.
9. Preferably, the pond should be rectangular in shape.

B] Recommendations for Preparing Ponds for Stocking

1. Remove excess pond bottom mud and dry pond bottom.
2. Ensure pond is not leaking and is deep enough. Undertake the necessary repairs.
3. Screen the inlet and outlet.
4. Treat the bottom of the pond with lime, if needed such as if pond cannot drain completely.
5. Ensure there are no live fish left in the pond.
6. Fill the pond.
7. Maintain pond record sheets with the details of any management treatments.
8. Check pond water quality before stocking.
Plate 3.1: Predation by a Wading Bird in Shallow Water
Wading birds are only able to enter and hunt in ponds they can step down in. (Picture of courtesy of Uganda Wildlife Authority)

Plate 3.2: Aquatic Weeds Growing in a Shallow Pond
Plate 3.3: Fish Escaping through an Un-Screened Inlet
Fish swim against the current. They often escape from ponds by swimming out the inlet. This is an extreme example.

Plate 3.4: A Dislodged Standpipe
Poor anchorage of the standpipe frequently results in the standpipe becoming dislodged from just below the bend.
Plate 3.5: **Kingfisher Nests within the Freeboard**
Potential predators such as the kingfisher as well as termites build their nests in the *freeboard*. The nests eventually become points through which leakages can occur.

Plate 3.6: **Harvest Basins**

a. A Harvest Basin Set Within the Pond.

b. A Harvest Basin Set Outside a Pond.
a. Overhead Picture of Inlet Properly Screened with a Sock. The inlet pipe should be set at least 20 cm above the water surface to prevent fish from swimming out of the pond. However, if protected by a filter sock, the drop is not so important.

b. A Properly Screened Outlet. Note that the cone mesh screen is set inside the standpipe. The standpipe should be cut to 10 cm above the intended maximum water level to collect rain water. Otherwise, when it rains, the precipitation will just wash out the overflow. However, make sure the standpipe level is lower than the pond levee.

Plate 3.7: Proper Screening of Inlet and Outlet Pipes
a. A Dry Pond Bottom.
After draining, the pond should be left to dry before the next cycle.

b. Limed Pond.
Lime spread uniformly over the pond bottom in a catfish nursery pond to kill diseases and parasites and to ensure that there are no catfish left in the pond before re-stocking.

Plate 3.8: Pre-stocking Treatment
CHAPTER 4:

STOCKING PONDS

Putting fish into the pond, stocking, marks the beginning of a production cycle. It is among the most stressful processes the fish go through in the course of production. The process of stocking referred to here, starts with the collection of fingerlings from the hatchery, transporting them to the farm and, finally, putting them into the pond. Poor stocking procedures, are among the major causes of low survival in grow-out ponds. They result in disease, reduced growth and mortality. However, because the ensuing mortalities do not occur normally until after about three days, and many of the fish that die do not actually come up to the surface, many farmers do not recognize it as a serious factor.

Upon draining the pond the farmer often experiences many fewer fish than the number stocked. This makes most farmers think the fish were either stolen, predated upon or the said number was not received. Farmers who do not realize that most of their fish died within the week following stocking, tend to overfeed and can lose a lot of money. For this reason, a month of nursery phase is recommended (see appendix 2 for summary recommendations for nursery pond management). After 1 month, the small nursery pond is harvested and the fingerlings, which by this time are larger and more resistant to handling, are weighed and counted into the larger production pond.

Successful stocking depends upon the quality of fingerling, how they are stocked and when they are stocked.

4.1. Quality of Fingerlings

The third most important factor, that affects production and returns in pond culture after nutrition and environmental (water) quality, is the quality of fish stocked. Stock quality does not just refer to the genetic make up of the fish. It also refers to the general health, relative size and other physical and physiological characteristics of the fish. Practically, every farmer should be in position to assess the physical characteristics and physiological status of good fingerlings. Poor quality stock will give poor production performance regardless of other factors.
Chapter 4– Stocking Ponds

The most important practical criteria for assessing the quality of catfish fingerlings are source, physical appearance and how they swim.

4.1.1. The Source of Fingerlings
Preferably, purchase fingerlings from a hatchery that follow Best Management Practices (BMPs) for catfish seed production.

A well-run fish hatchery:
1. Can guarantee the good quality of fingerlings or stockers it supplies.
2. Has a good reputation among other farmers (check with other farmers)
3. Follows the stipulated BMPs for hatcheries (see appendix 3). The manner in which fish are reared and handled within the hatchery directly affects their health status, survival and potential to perform.
4. The hatchery should have adequate facilities to hold and condition fish before live transportation.
5. Keeps good hatchery records. The hatchery should have a proper record system that enables them as well as the buyer to trace the lot of fish purchased down to the batch in case of any questions.
6. Provide fingerlings above 10cm.

4.1.2. Physical Characteristics
The fingerlings should be of a uniform color and size. Catfish fingerlings usually are darker (blackish) on the top and lighter (creamy) around the belly (see Plate 4.1a). Do not purchase the fish if:
(i) several of them have patches over their body,
(ii) they have less than two barbels, no tail or missing fins,
(iii) they show signs of physical injury or bleeding,
(iv) they are deformed (see Plate 4.1b),
(v) they are less than 10cm in total length.

These are signs of poor condition. Such fish are likely to be already diseased and are less likely to survive transportation or stocking.

It is important to stock fish of uniform size otherwise the larger fish will cannibalize the smaller ones. They will also dominate the feeding area which will result in them growing bigger and the smaller fish remaining small. In such a situation, at harvest, there will be only a few extremely
large fish (*shooters*) and several tiny fish of unmarketable size. Survival rates from *stocking* to harvest in this case will be extremely low.

### 4.1.3. Physiological Characteristics

The *fingerlings* in the holding unit in the hatchery should be swimming normally and should be active. Fish remaining up-right, that are sluggish and do not respond to stimuli or prefer to be isolated from the rest of the group, are unlikely to be well (see Chapter 7 for more details). Do not purchase and *stock* such fish.

### 4.2. Stock Stress-Free Animals

The fish should be *stress free*, lively and active. *Stressed* fish start dying about three days after *stocking* and mortalities can continue for up to a week. It should be noted that, not all the dead fish float to the surface. As has been mentioned above, *stress* associated with *stocking* is among the major causes of low survival. However, because the deaths do not occur immediately and dead fish are often picked up by birds at dawn or dusk, many farmers fail to link the ensuing mortalities and low survival with poor handling at *stocking*. Minimising *stress* associated with *stocking* starts at the hatchery. Therefore, take note of the following when you intend to *stock* your ponds.

#### 4.2.1. Place the Order for Fingerlings from the Hatchery in Advance

Order the *fingerlings* at least four days in advance. Re-confirm your collection time for picking up the *fingerlings* a day or two before the receiving day. This is to give ample time to the hatchery operators to sort, grade and *condition* the fish a few days before they are transported to the grow-out farm.

To enable the hatchery operators sort and grade the right fish and pack it for transportation appropriately the following information must be given when placing your order.

1. The number and sizes of ponds you intend to *stock*.
2. How many fish are to be *stocked* into each of the ponds?
3. Size of fish you require. The minimum recommended size for *stocking* catfish grow-out ponds is 10 cm or 5g. *Stocking* larger *fingerlings* (from 10 g up) though is preferable.
4. The destination (location of farm) i.e. how far to travel.
5. On which day and at what time you intend to collect the fish.
6. How you propose to transport it. For example, if you are to use public transport, either you or the hatchery operator might need to arrange for packing boxes so that the transport bags remain secure in the bus.

4.2.2. **Handling at the Hatchery.**

A hatchery that follows BMPs, should be in a position to undertake the following, to ensure that the fish collected are not stressed, and that they are in the best condition for stocking.

1. **Fish should be Conditioned for 48 Hours before Collection.** To prepare the order, the fingerlings have to be seined, sorted, graded, counted and then held in holding facilities (either tanks or hapas) with good water quality and aeration as needed, for at least two days prior to collection. The fingerlings are to be left in these holding units without feed until the collection day, but for not more than 3 days. This process is termed ‘conditioning’ the fish. Conditioning provides time for the fish to empty their guts before transportation and for the weak/deformed fish to be identified and removed. Do not transport fish with full guts because they will defecate and vomit in the transportation container, which reduces the water quality by increasing the levels of ammonia and organic load. When their guts are full, the fish require extra levels of oxygen to enable them breakdown the food in their guts. This results in a more rapid depletion of dissolved oxygen levels within the transport container. Holding fish prior to transportation in conditions of poor water quality is extremely stressful, and is a major predisposing factor for disease and mortality. Do not transport fish for stocking that have not been conditioned for at least 48 hours in good holding conditions.

2. **Estimate Counts by Weight or Volumetrically.** Counting fish one-by-one is extremely stressful especially for the young stages. At this sensitive stage, fingerlings should always be kept in water. It is least stressful, therefore, to have the numbers estimated volumetrically or by weight. For example, if the average weight of the fish is 10 g, then 1 kg of fish should be equivalent to approximately 100 fish (i.e., $1,000g/10g = 100$). Fish counted in this way are least stressed and there are fewer reported losses during transportation and at stocking. It also requires less labour, so the hatchery should be in position to give 5% of the total number of fingerlings purchased for free to cover for any possible shortage.
3. **Package for Live Transportation.** When you arrive at the hatchery, fish should be packed for live transportation in either bags with oxygen or in tanks with aeration. Each bag should receive its fish after your arrival and immediately have the air evacuated and oxygen added. A bag should be done completely from adding fish to oxygen at a time. The hatchery should not allow bags with water and fish to remain in line awaiting oxygen otherwise by the time this is done, the fish will have been held for a while in water devoid of oxygen *(stressed)*.

In addition, the bags or tank should not be overloaded with fish. The general *stocking* rate for oxygenated transport bags is 1 to 2kg of *fingerlings* for every 10 litres of water (100-200 g/L) depending on the size of fish, transport condition and distance to travel. Smaller fish require about four times more oxygen than adults.

Furthermore, each bag should be labelled individually with a tag providing the information shown in figure 4.1 below.

- Hatchery Name and Contact Details
- Fish Species
- Number/Weight of fish in bag
- Average Weight of Fish (g)
- Lot or Batch No. (this should be traceable back to unit from which the fish were obtained and the date of harvest)
- Estimated DOB (Date of birth) (fish sold as a lot or batch should be within a month old from each other)
- Any other Specifications or Required Details (e.g. if selected stock; intended destination - *e.g. Johns farm, pond C*, etc.)

**Figure 4.1:** Recommended Labelling for Containers used in Live Haulage of Fingerlings to Farms.

The objective of having each bag labelled independently is to:

1. **Assure Quality.** The hatchery commits itself to the contents in the bag at packing.

2. **Minimise the Amount of Physical Handling.** When each bag is packed and labelled for its final destination (*e.g. grow-out pond B*), the grow-out farmer can *stock* his ponds without having to touch or count his fish again, except for removing those that might die or are too weak to *stock*. This reduces the levels of handling stress associated with *stocking* grow-out ponds. More than one bag might
be required per pond depending on its size because the bags should not be overloaded with fish.

3. **Ensure the Fish are in Good Quality Water up to Stocking.** Once a bag packed with oxygen is opened, the oxygen escapes immediately out of the bag. The *fingerlings* will quickly consume and deplete the remaining oxygen in the water. Therefore, if the fish from one bag need to be divided among different places, the lengthy *stocking* time results in the last fish being *stressed* from low oxygen. The last fish will have literally been suffocated though they might still be moving. Losses in such a case will subsequently be very high soon after *stocking* and survival rates at harvest low. If fish from the bag must be counted and divided for *stocking*, the water in the bag must either be *aerated* or the fish moved to a larger volume of good quality water or a tank with flowing fresh water. (For more details on the recommendations for packing fish for live fish transportation, see appendix 4).

4.2.3. **Live Transportation of Fingerlings from Hatchery to the Farm**

The survival of the fish enroute from the hatchery to the farm is the transporter's responsibility. Transportation should be as *stress*-free as possible. Consequently, it is extremely important that the transit time to the farm is minimised to the utmost. Do not stop to run errands after collecting fish from the hatchery. Rather complete all your errands before collecting the *fingerlings* from the hatchery. This is because:

1. By simply being crowded and confined in containers, the fish are subjected to *stress*. In addition, they will still be releasing metabolic wastes into the water in which they are being transported. While the levels of waste (notably the solid wastes) they release will have been minimised as a result of the 'conditioning' process, dissolved wastes (e.g., ammonia and carbon dioxide) will still be released. The longer the transportation time, the more these wastes will accumulate and the more *stressed* the fish will be.

2. The polythene bags in which *fingerlings* are transported act as a greenhouse. If left out in direct sunlight, the water in the bags can become extremely hot (to above 32°C) within a few hours. Rapid changes in temperature or extreme temperatures are extremely
stressful to the fish and result in fatigue and eventually mortality (see table 4.1 below). Therefore, keep the transport containers or bags shaded and cool during transportation. If the fingerlings are being transported at the back of a pick-up for example, cover bags/tank with wet sisal gunny bags, mats or banana leaves. This will help keep them shaded and cool. The darkness also helps keep the fish calm. Bags should also be placed in boxes, basins or baskets to help support them during transportation and prevent punctures (see Plate 4.2).

Caution!!
1. If at any time during transport, the bag deflates, it means the oxygen has left the bag and the fish will die soon. The only way to keep your fish alive after the oxygen has gone from the bag is to keep changing the water. CAUTION: Replacement water should be of equal quality and similar temperature; otherwise, the fish will be stressed even more. If the bag begins to deflate soon after you have left the fingerling vendor, you should return to the vendor and ask them to change the bag and to add more oxygen and re-close the bag.

2. Do not transport fish for more than twenty minutes without some form of aeration because the oxygen levels drop to zero within less than five minutes in containers (see table 4.1). Remember all living things need oxygen. Once the dissolved oxygen levels approaches zero, fish will begin to die. Larger catfish are, however, air breathers and can survive by gulping air at the surface. They need to be able to get to the water surface in order to survive.

3. If you are transporting fingerlings in a transport tank with aeration, do not change the water simply because the temperature has risen unless it is over 30 °C. It is more important to have adequate levels of oxygen within the tank.

NOTE: It is worth spending an extra bit of money to ensure that the fingerlings are packaged as recommended. Fingerlings are one of the major operating costs. Any losses will result in loss of profits.
## Table 4.1: Water Quality Changes in Live Fish Transport Containers

<table>
<thead>
<tr>
<th>Type of fish</th>
<th>Reason for transport</th>
<th>Type container</th>
<th>volume of water in container (litres)</th>
<th>average size fish (g)</th>
<th>amount fish (kg)</th>
<th>Aeration (yes/no)</th>
<th>type aeration (oxygen/air)</th>
<th>Readings at Departure</th>
<th>Readings at Destination</th>
<th>Transit Time to Destination</th>
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</thead>
<tbody>
<tr>
<td>tilapia</td>
<td>transfer from one pond to another on the same farm</td>
<td>basin</td>
<td>15</td>
<td>5</td>
<td>3.0</td>
<td>no</td>
<td>none</td>
<td>4.92</td>
<td>25.5</td>
<td>2.62</td>
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<tr>
<td>tilapia</td>
<td>transfer from one pond to another on the same farm</td>
<td>basin</td>
<td>20</td>
<td>5</td>
<td>3.0</td>
<td>no</td>
<td>none</td>
<td>5.2</td>
<td>26.1</td>
<td>3.43</td>
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<td>tilapia</td>
<td>transfer from one pond to another on the same farm</td>
<td>basin</td>
<td>20</td>
<td>5</td>
<td>4.0</td>
<td>no</td>
<td>none</td>
<td>5.6</td>
<td>25.8</td>
<td>2.61</td>
</tr>
<tr>
<td>tilapia</td>
<td>stocking on another farm</td>
<td>tank</td>
<td>200</td>
<td>10</td>
<td>75.5</td>
<td>yes</td>
<td>air</td>
<td>7.52</td>
<td>27.8</td>
<td>4.9</td>
</tr>
<tr>
<td>tilapia</td>
<td>stocking on another farm</td>
<td>tank</td>
<td>200</td>
<td>3</td>
<td>23.0</td>
<td>yes</td>
<td>air</td>
<td>8.36</td>
<td>25.6</td>
<td>6.01</td>
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<tr>
<td>catfish</td>
<td>loading tank for transportation (reading before tank leaves hatchery)</td>
<td>tank</td>
<td>500</td>
<td>3</td>
<td>150.0</td>
<td>no</td>
<td>none</td>
<td>6.4</td>
<td>26.7</td>
<td>0.8</td>
</tr>
<tr>
<td>catfish</td>
<td>stocking on another farm</td>
<td>bags</td>
<td>20</td>
<td>3</td>
<td>1.5</td>
<td>yes</td>
<td>oxygen</td>
<td>6.3</td>
<td>22.4</td>
<td>2.9</td>
</tr>
<tr>
<td>catfish</td>
<td>bait (loading jerry can)</td>
<td>jerrycan</td>
<td>10</td>
<td>10</td>
<td>2.0</td>
<td>no</td>
<td>none</td>
<td>5.4</td>
<td>24.5</td>
<td>1.3</td>
</tr>
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</table>
4.3. Size to Stock

_Fingerlings_, stockers or sub-market sized fish can be stocked into ponds for grow-out production (see table 4.2).

**Table 4.2:** Description of Catfish Sizes Recommended for Stocking Grow-out Ponds.

<table>
<thead>
<tr>
<th>Size Description</th>
<th>Length (cm)</th>
<th>Average weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fingerlings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small fingerlings</td>
<td>7-10</td>
<td>3-6</td>
</tr>
<tr>
<td>Medium fingerlings</td>
<td>10-12</td>
<td>6-9</td>
</tr>
<tr>
<td>Large fingerlings</td>
<td>12-15</td>
<td>9-20</td>
</tr>
<tr>
<td>Extra large fingerlings</td>
<td>&gt;15</td>
<td>20</td>
</tr>
<tr>
<td><strong>Stockers</strong></td>
<td></td>
<td>21-100</td>
</tr>
<tr>
<td><strong>Sub-market</strong></td>
<td></td>
<td>100-399</td>
</tr>
<tr>
<td><strong>Table size</strong></td>
<td></td>
<td>+400</td>
</tr>
</tbody>
</table>

The minimum recommended _stocking size_ for grow out ponds, however, is 10cm (6g). This is because fish of this size are able to avoid predation from other water life, overcome minor stressful situations and can ably swim across the ponds to feed. If good quality fish are stocked, fed and managed properly, survival rates at harvest can be very good (see table 4.3 below).

**Table 4.3:** Size at stocking versus survival rates at harvest in ponds managed as grow-out catfish ponds.

<table>
<thead>
<tr>
<th>Size at stocking (g)</th>
<th>Survival rate at harvest (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3-1.5</td>
<td>6-20</td>
</tr>
<tr>
<td>1.5-3.0</td>
<td>19 - 30</td>
</tr>
<tr>
<td>3-5</td>
<td>30 - 50</td>
</tr>
<tr>
<td>5-10</td>
<td>40-60</td>
</tr>
<tr>
<td>10-50</td>
<td>60-90</td>
</tr>
<tr>
<td>50-100</td>
<td>80-100</td>
</tr>
<tr>
<td>+100</td>
<td>90-100</td>
</tr>
</tbody>
</table>

Data from USAID FISH Project Farm Trials (2005-2008).

Never _stock_ fish that are too small in a grow-out pond because the low survival reduces profit margins as well as raising the costs of production.
**Box 2: The Actual Cost of Stocking Grow-Out Ponds with Fish below the Recommended Size**

**EXAMPLE:** A farmer has a grow-out pond of 1,000m² and intends to stock it with 2,000 catfish. However, the farmer has been presented with two options, fry of an average weight of 3g at USh. 100/= each or large fingerlings of an average weight of 10 g each at 200/= each. Which of the two sizes will give the best production results and returns?

<table>
<thead>
<tr>
<th></th>
<th>Option A (stock fry)</th>
<th>Option B (stock fingerlings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average weight of Catfish to Stock (g)</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Unit Cost (USh.) at hatchery</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Total Amount Spent for Fish Stocked (USh.)</td>
<td>200,000</td>
<td>400,000</td>
</tr>
<tr>
<td>Expected Survival Rate (%)</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Estimated Number of fish at harvest</td>
<td>2000 fish x 30</td>
<td>2,000 fish x 70</td>
</tr>
<tr>
<td></td>
<td>600 fish</td>
<td>1,400 fish</td>
</tr>
<tr>
<td>Actual Cost of Each Catfish Stocked (USh.)</td>
<td>200,000/=</td>
<td>400,000/=</td>
</tr>
<tr>
<td></td>
<td>600 fish</td>
<td>1,400 fish</td>
</tr>
<tr>
<td></td>
<td>333/=</td>
<td>285/=</td>
</tr>
<tr>
<td>Months required to attain market size</td>
<td>About 8 months</td>
<td>6 months</td>
</tr>
<tr>
<td>Number of fish that will be available for sale at harvest</td>
<td>600 fish only</td>
<td>1,400 fish</td>
</tr>
</tbody>
</table>

**NOTE:** You may not always be saving money by stocking fry rather than fingerlings of the recommended size just because they are cheaper. Make the decision after knowing what survival rates you are likely expect and check the cost. If you only have access to fry, raise them in a nursery pond to fingerling size first.

Therefore, because survival rates are low when grow-out ponds are stocked with fish of 5 g or less, it is recommended that such fish are first stocked into a nursery pond for about a month until they get to a size of about 50g. Stocking fingerlings from the hatchery into a nursery pond prior to stocking in a production pond presents the following advantages:

1. it is easier to protect a small pond from predators,
2. the higher stocking densities in nursery ponds allow for easier feeding of the fry or fingerlings,
3. it enables the farmer avoid the situation of wasting feed for a whole cycle because when he empties the nursery pond, the farmer will be in position to count exactly how many fish will have survived and are stocked into the grow-out pond (see appendix 2 for more details on catfish nursery pond management).
4.4. Stocking Rates

It is recommended that fish be stocked based on the pond's carrying capacity vis-à-vis the targeted market size. This is because a pond is an ecosystem which has a maximum load that it can safely support. Consequently, when overloaded beyond its limits, instead of having a favourable environment for production, the result is a polluted system that cannot support production. The pond’s water quality starts to deteriorate because the pond’s systems can no longer effectively break down and assimilate wastes. If the situation worsens, fish experience disease and mortality (See figure 4.2). Once the pond’s carrying capacity has been attained, the fish will cease to grow no matter how long they stay in the pond. Production and returns actually start to diminish ('point of diminishing returns') at "critical standing crop" prior to reaching the carrying capacity. The carrying capacity for static water catfish monoculture ponds in southern Uganda when fed nutritionally-complete diets can be estimated at about 20 tons/ha (or 2.0 kg/m²).

**Figure 4.2:** How the total biomass in the pond changes as carrying capacity is reached

Figure 4.2 illustrates how change in biomass declines and almost becomes static with time when carrying capacity has been attained. If there were 20,000 fish in this pond, they would not grow to a very large size.
A pond’s *carrying capacity* is influenced by:

1. the size of fish in the pond (because this influences the feeding rate)
2. the species of fish being raised because fish like clarias become air breathers and do not need to rely on dissolved oxygen in the pond, therefore the *carrying capacity* is higher for clarias compared to tilapia
3. the amount and type of feed or fertilizer added to the pond
4. the water volume and quality (see Chapter 5 for more discussion.)

Therefore, the number of fish to be stocked depends not just on the targeted market size, but additionally, on the way the pond was constructed, the type of feed used and the pond management program. The *carrying capacity* of a nursery pond is also different from that of a grow-out pond because the fish are fed a higher percent body weight. The *carrying capacity* of a catfish nursery pond is about 5,000 kg/ha (or 0.5 kg/m²).

**Equation 1** below illustrates how the number of fish to be stocked in a pond can be estimated based on the pond’s *carrying capacity*.

\[
\text{Number to stock} = \frac{\text{Estimated maximum carrying capacity of a pond (kg)}}{\text{Desired weight at harvest (kg)}} + 10\%
\]

The 10% is to cater for mortality. Note that it is best to use *critical standing crop* but most farmers base *stocking* on *carrying capacity* with the understanding they will do a partial harvest as growth begins to slow.
The “split-stocking” management option

In order to get the most from their ponds, farmers will often elect to stock at high density with the intention of splitting the total fish number into multiple ponds before the fish reach market size. This can be done in many ways. Typically the farmer will stock about 3 times as many fish as the pond could hold and then harvest out 2/3 of them after a few months and put them into 2 more ponds. For example, if a farmer knows that pond A should be able to hold about 1 ton of catfish and the final size desired is 600 g, then the pond should have about 1,000 kg/0.6 kg = 1,667 fish at harvest time. Let’s say the farmer would stock 2,000 to cover for any losses. However, the farmer can stock 6,000 and then when the total calculated population gets close to 1,000 kg, seine the pond and remove 4,000 fish. Those 4,000 fish can be put into 2 more ponds of the same size, thus resulting in 3 ponds of 2,000 fish each.

Many farmers have found this option to be desirable because they can renovate one pond first and while they are renovating the other 2 ponds, their fingerlings can be growing out in a nearby pond. When they make the split, they can even grade the fish so one pond receives the larger fish and another receives slightly smaller fish.
Box 3: Example of How to Calculate the Number of Fish to Stock

EXAMPLE: The size of pond to be stocked is 1,000 m². The size of fingerlings is 15 g and the targeted size for harvest is 800 g. The intended management regime is catfish monoculture fed entirely on commercial nutritionally-complete pellets in static water ponds. How many fish should be stocked?

The critical standing crop for catfish monoculture fed commercial pellets is estimated at 1.8 kg/m² (18 tons/ha). Add 10% to account for mortalities.

\[
\begin{align*}
&= (1,000 \text{ m}^2 \times 1.8 \text{ kg/m}^2) + 10\% \text{ of } (1,000 \text{ m}^2 \times 1.8 \text{ kg/m}^2) \\
&= 2,250 + 225 \\
&= 2,475 \text{ fingerlings should be stocked}
\end{align*}
\]

NB: Cross check that the daily amount of food required to feed the fish as they approach harvest does not exceed 20 g of feed/m² pond area. Use the feeding chart (see appendix 5) to help you make this estimate. If it will exceed the limits, reduce the stocking rate or plan on using a flow-through system.

Therefore, in this case, assuming a survival rate was 90% (i.e. 225 fish died), we can estimate that there shall be 2,250 fish of an 800 g average weight at harvest.

Therefore, the amount of feed that will be required per day when fish are at about harvest size.

\[
\begin{align*}
&= \text{Daily Feed/Fish (g)} \times \text{No. of fish in the Pond} \\
&= 8.9 \text{ g} \times 2,250 \\
&= 20,025 \text{ g of feed/day} \\
&= 20.1 \text{ kg of feed would be required to feed the 1,000 m² pond when the fish are ready to harvest.}
\end{align*}
\]

However, not more than 20 g of feed per m² per day should be fed to non-aerated static water ponds otherwise water quality problems might arise. Therefore, in this case, the maximum feed amount that can be added a non-aerated pond of 1,000 m² is:

\[
\begin{align*}
&= 20 \text{ g feed m}^2 \times 1000 \text{ m}^2 \\
&= 20 \text{ kg feed/day}
\end{align*}
\]

For this case, therefore, we are relatively safe and can stock the actual number that was calculated. If our projected feed requirement at harvest would have exceeded the safe limit, then (i) we would have had to reduce the number of fish to stock in order that by harvest our projected feeding rate would be within safe limits, or (ii) as we approach the daily feed limit, we could do a partial harvest, thereby reducing the amount of feed required per day, or (iii) we could begin flushing water through the pond to wash out the wastes.

The same procedure should be used to estimate the number of fingerlings to stock in a nursery pond.
4.5. When to Stock

Ponds should be stocked as soon as possible after they have been filled with water. Remember to check that the water quality in the pond is suitable for stocking especially if pre-stocking pond treatments have been done a day or two before the planned stocking date. Set your stocking date to suit your market's needs.

4.5.1. What Is The Best Time Of Day To Stock The Pond?

The best time of day to stock the pond depends on the water quality (notably oxygen levels, temperature and pH) and not particularly on the hour of the day. It is recommended that the pond be stocked when the pond's water quality is at its best. The dissolved oxygen levels should preferably be not less than 5 mg/L (5 ppm), water temperature not less than 25 °C, and pH levels between 7 and 7.5 at stocking.

The other consideration one must take into account is one's work schedule. When stocking the pond, one must have the time to be present to monitor the fish during and a couple of hours after the stocking process. Therefore, it is preferable to stock during the day, and not at night.

4.5.2. Intervals between Stockings

At times it may not be possible to get all the fish required to stock the pond at once. In the event that this happens, do not stock fish more than two weeks apart because by then there will literally be two entirely different populations. Fighting and subsequently stress and lower survival rates may ensue. Also, remember that the lot stocked first will be growing in the mean-time and it is important to have uniform sizes stocked into the pond, to avoid cannibalism.

4.6. How to Stock

Stocking should be done in a manner that minimizes stress to the fish. Stress results in mortalities and disease outbreaks. Therefore, do not pour the fish straight into the ponds. Acclimatize the fish first over 15 to 30 minutes and gently release the fish into pond. This helps them adapt to the differences in water quality between the transport container and the pond without shocking the fish. When fish are shocked by the sudden changes in water quality, they become stressed or die. Temperature, oxygen, mineral content and pH are the key parameters for which acclimation needs be done for catfish fingerlings. Allow 15 minutes for every degree change in temperature and for every unit change in pH.
4.6.1. **Guidelines for stocking fish from bags.**

The following are the recommended steps to follow when stocking fish into ponds from bags.

1. **DO NOT open any of the bags before they get to the pond.** This is because once a bag is opened, all the oxygen in the bag will leave into the atmosphere. The fish only have about 5 to 10 minutes before they run out of oxygen after a bag has been opened.

2. **Set the bags right next to the pond (keep bags in basket or box to support the bag) or just in the pond.** You are going to add water to the bag, so it may be too heavy to move after that.
   
   If you have the equipment, check the water quality parameters of the pond before opening the bags and the water quality within the bags as well as during the course of acclimation, especially for temperature and oxygen.

3. **Open one bag at a time.** Begin with the bag that is least inflated.
   
   If you have no tools for checking water quality, use your fingers to detect for any obvious temperature differences between the pond water and water in the bag.

4. **Add water from the pond into the bag.** While doing this, you can allow the other un-opened bags to float on the pond. This will allow the other bags to adjust to the pond temperature. Cover these bags to shade and prevent excessive sunlight.

   **NOTE:** Floating the un-opened bags on ponds alone is insufficient to acclimatize the fish properly. This is because bags used for packing fish for grow-out ponds are large and the bag often contains much more fish unlike those used to pack ornamental fish for stocking aquaria.

5. **Add small amounts of water from the pond into the bag over 10 to 20 minutes to allow the temperature and water quality (e.g., pH) of the transported water to slowly become similar to that of the pond water.**

6. **The total amount of water added should be double or triple the amount already in the bag.**

7. **Then lower the bag in the pond and tip it so that the fish can swim out on their own.** Observe how they swim out.

   **NOTE:** Pouring fish from a bag or throwing them into the pond can be stressful. It is best to let them swim out of a bag or out of a net by themselves. In some countries, lakes are indeed stocked by dropping the fish from airplanes, but survival is not reported.
4.6.2. Guidelines for stocking from transport tanks/containers

1. Drive down as close as possible to the pond.
2. Check the water quality in the pond and in the tank.
3. With a bucket, remove about a third of the water in the tank. Then add pond water. Repeat this process 2 times giving time for the parameters to gradually re-adjust as mentioned in 4.6 above.
4. Scoop out a few fish at a time into a bucket with adequate water using a scoop net.
5. Gently lower bucket in water and let fish swim out on their own.

NOTE:

1. Keep the aeration going in the tank right through the process until all the fish have been stocked.
2. It is important to stay around and observe how the fish swim out of the bag or container. Any fish that lie immediately on the pond bottom will likely die within a day or two. Fish that swim erratically or have any discoloration on their bodies or fins may die within 2 to 4 days. If the fish swim back into the container, it is probably due to the fact that the water current has reversed (fish swim against the current). Be around to ensure no birds take the fish during stocking or soon after.

4.7. Records

Record all the stocking information including the source of the fingerlings, average size stocked, total number and kilograms stocked as well as any notable observations during the stocking process in the pond’s management record sheet (see Chapter 9 for more details on how to fill in the record sheet and figure 9.2 (pages 155-156) for an example of a FULLY filled record sheet). Watch closely for any mortalities after stocking and record them as numbers, or, if the number is too high, estimate number based upon the total weight and a sample.
Summary Guidelines for the Stocking of Catfish Grow-Out Ponds

1. At the hatchery, take note of the following:

   a. *Fingerlings*/stockers should have been *conditioned* prior to packaging for transportation. This means held in separate units and not fed for at least 24 - 48 hours prior to transportation. *Conditioning* also makes it possible for the hatchery to select fish in good condition. Therefore, inform the hatchery at least 3 days in advance if you are to get well *conditioned* fingerlings or stockers to stock your pond.

   b. Check the size of fish being packed. It should be what you ordered for.

   c. Each individual bag should be labeled as follows: *size of fish, number of fish, age of fish, species of fish, hatchery batch no.* This is important information because it enables you:
      - reduce the need to count fish at stocking which minimizes stress to the fish from to physical handling.
      - determine the initial feed type and feeding rates to use
      - traceability and quality control.

2. When Stocking Catfish Grow-out Ponds:

   a. Fill pond to the recommended average pond water depth of 1 meter.

   b. *Stock* fingerlings of not less than 10 cm (above 5 g) average length. It is highly recommended that the *fingerlings* (especially if they are less than 10 cm) be *stocked* first into a *nursery pond* for about a month when they are stockers 30-50 g average weight.

   c. After a month, drain the *nursery pond* and *stock* the stockers into the *grow-out pond*.

   d. *Stock* both the nursery and grow-out ponds based on the intended size at harvest and its *carrying capacity*. The *carrying capacity* for catfish *nursery ponds* fed complete diet commercial sinking pellets is 5 tons/ha and of *grow-out ponds* (32% Crude Protein) is 15 - 18 tons/ha.

   e. Prior to *stocking* assure that the inlet has at least a 20 cm drop to maximum water level AND has a *filter sock* on the pond side. This will prevent *fingerlings* from swimming out of the inlet.

   f. The area immediately surrounding the inlet should be protected from wading and diving birds on days when water flows into the pond. The catfish tend to congregate near the water inflow and make picking them easy for birds.

   g. *Acclimate* the fish adequately before releasing them from the bag or tank into the pond.

3. Records:

   Record the source, type, number and weight of fish you have *stocked* as well as any other observations associated with *stocking* in the pond record sheet.
a. **Good Quality Catfish Fingerlings.** Note the uniform size, uniform colour patterns, all body parts intact.

b. **Poor Quality Catfish Fingerlings.** Note the white patches on the body, missing body parts.

Plate 4.1: Physical Characteristics of Good Catfish Fingerlings

---

a. **Packing Fingerlings for Live Transportation in Bags with Oxygen.**

Note the double bagging. It is important to do so to reduce the risk of loss of oxygen in the event of a puncture in either layer during transportation.

b. **Transporting Fingerlings Packed in Bags to Farm.**

Bags should be placed in boxes, basins or baskets to help support them during transportation and prevent punctures.

Plate 4.2: Packaging and Transporting Fingerlings in Bags with Oxygen

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CHAPTER 5:

WATER QUALITY AND GENERAL POND MANAGEMENT

Water quality is the first most important limiting factor in pond fish production. It is also the most difficult production factor to understand, predict and manage. Water is not just where the fish live. Its quality directly affects feed efficiency, growth rates, the fish’s health and survival. Most fish kills, disease outbreaks, poor growth, poor feed conversion efficiency and similar management problems are directly related to poor water quality.

Water quality refers to anything in the water, be it physical, chemical or biological that affects the production of fish. The objective of pond management, is to manage the water quality, so as to provide a relatively stress free environment that meets the physical, chemical and biological standards for the fishes normal health and production performance.

Within a pond, water quality is a product of:
1. the quality of water at the water source,
2. the quality of the pond soils and immediate environment,
3. production technology and management procedures employed, notably those associated with feeding, the maintenance of adequate dissolved oxygen as well as any other chemicals or inputs applied.

5.1. The Water Quality Requirements for Catfish Production and their Relevance to Production

The key water quality parameters for pond production are temperature, oxygen, pH, alkalinity, hardness and nitrogenous waste. In table 5.1 below, the recommended values for the key parameters are listed. However, due to the dynamics within the pond, they fluctuate daily depending upon photosynthesis of aquatic plants like algae, the production management technology employed and local weather conditions.
### Table 5.1. Relevance of Water Quality Parameters to Pond Production

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Relevance to Production</th>
<th>Recommended Range</th>
<th>What happens when Consistently below recommended Value</th>
<th>What happens when consistently above recommended value</th>
</tr>
</thead>
</table>
| **Dissolved Oxygen**  | • Fish breathe in oxygen for their metabolism.  
• Dissolved oxygen is needed to oxidise potentially toxic metabolic wastes into less toxic forms (e.g. ammonia (NH₃) to nitrite (NO₂⁻) and then nitrate (NO₃⁻)).  
• Bacteria in ponds that help transform wastes into less toxic products need oxygen for metabolism.  
• *Phytoplankton* use oxygen at night during respiration.  
|                       | From 4 mg/l to saturation for catfish eggs, larvae, fry and fingerlings. As catfish develop, their accessory breathing organs enable them get oxygen by gulping at the water surface when dissolved oxygen levels are low. However, even adults will perform better when the dissolved oxygen levels are adequate. | • 0 – 1.5 mg/l can be lethal especially if exposed for long periods  
• 1.4 – 5 mg/l-fish survive, but reduced feed intake higher FCRs, slow growth, stress, and increased susceptibility to disease results. Build up of toxic wastes because they are not broken down (oxidised) | • Gas bubble trauma when the water is supersaturated to levels of 300% and above.                                                                                                                                                                                                                                                                                                                         |
| **Temperature**       | • Fish are cold blooded animals. Their rate of metabolism is directly influenced by water temperature.  
• Rate at which wastes in pond are broken down and chemicals dissolve is faster in warmer waters  
• Affects the solubility of | 26 to 32 °C                                                                       | • Below 15 °C. Growth stops and death occurs at extremes  
• 15 to 26 °C. Reduced feed intake and growth rates. Higher FCRs. Fish more stressed at lower temperatures, therefore, more susceptible to disease.                                                                                                                                                                                                 | • Lower solubility of oxygen, stress and death at extreme temperatures.                                                                                                                                                                                                                                                                   |
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Relevance to Production</th>
<th>Recommended Range</th>
<th>What happens when consistently below recommended Value</th>
<th>What happens when consistently above recommended value</th>
</tr>
</thead>
<tbody>
<tr>
<td>oxygen.</td>
<td></td>
<td></td>
<td>• Organic matter and other wastes are broken down at a slower rate when temperatures are low with high risk of eutrophication.</td>
<td></td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>• Affects the solubility and chemical forms of various compounds some of which can be toxic.</td>
<td>6.5 to max 9</td>
<td>• Below 4, acid death point.</td>
<td>• 9 - 11 Stressful for catfish, slow growth rate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 4 - 6.0. Survive but stressed, slow growth, reduced feed intake, higher FCRs.</td>
<td>• Above 11 alkaline death point. All life, including bacteria in pond will die at this point.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Higher proportion of Total Ammonium Nitrogen is in the form of ionized ammonia, which is less toxic for fish.</td>
<td>• Higher proportion of Total Ammonium Nitrogen in the form of unionized ammonia in water, which is more toxic for the fish.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Low pH indicates high levels of dissolved carbon-dioxide</td>
<td></td>
</tr>
<tr>
<td>Alkalinity and Hardness</td>
<td>• In combination, influence the buffering capacity of the pond water. Hardness is composed mostly of calcium and magnesium, which affect the physiological condition of the fish. Alkalinity also controls the amount and form of carbon-dioxide in water.</td>
<td>Alkalinity &gt; 20 ppm Hardness &gt; 20 ppm Total alkalinity and total hardness above 60 ppm is desirable.</td>
<td>• Extreme fluctuations in pond pH levels during the day which is stressful to the fish.</td>
<td>• Water will be well buffered and diurnal fluctuations in pH will be less extreme</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Fish are under physiological stress</td>
<td>• Fish will be less stressed physiologically</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Low levels of primary production which results in lower natural sources of food.</td>
<td>• Young fish will have more natural food available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• However, hard water in catfish hatcheries should be avoided.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Relevance to Production</td>
<td>Recommended Range</td>
<td>What happens when consistently below recommended Value</td>
<td>What happens when consistently above recommended value</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Total Ammonia Nitrogen</td>
<td>• Ammonia by-product of protein breakdown. It occurs in both a toxic form (ammonia) and non-toxic form (ammonium) depending on the pH of the water.</td>
<td>Not more 0.3 – 2 mg/l of the toxic form (ammonia). The proportion of TAN in the form of ammonia tends is higher as the pH of the water increases above 7</td>
<td>• Fish are happiest when there is no or little ammonia in water.</td>
<td>• The fish succumb more to attacks by trematodes and other parasites.</td>
</tr>
<tr>
<td>(TAN)</td>
<td></td>
<td></td>
<td></td>
<td>• The fish fail to eliminate ammonia from their blood because there is too much ammonia already in the water. Ammonia is excreted by fish as a by-product of protein metabolism primarily through their gills. High concentrations of ammonia in water reduce the ability of the gills to do so.</td>
</tr>
</tbody>
</table>

*Table 5.1: Continued*
5.2. Managing the Water Quality Parameters

5.2.1. Dissolved Oxygen

Most of the dissolved oxygen in non-aerated fish ponds is generated as a result of photosynthesis by phytoplankton (microscopic plants). Some oxygen is also incorporated into the water from the air, especially when the wind blows over the water surface and creates water movement (mixing). Photosynthesis occurs only in the column where sunlight can penetrate because sunlight is a catalyst to the process (see equation 2 below). Sunlight in ponds penetrates to a depth of 30 to 80 cm depending on the levels of water turbidity. Therefore, only the water up to 70 cm to 1 m deep from the surface is oxygenated from photosynthesis in static water ponds. That is why there is no need to dig the pond deeper than the recommended maximum, especially if no additional mechanical aeration is available. Also, shade from trees will reduce sunlight penetration and photosynthesis.

\[
\begin{align*}
6\text{CO}_2 + 6\text{H}_2\text{O} & \xrightarrow{\text{sunlight}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \\
\text{Equation 2}
\end{align*}
\]

Equation 2 above illustrates the process of photosynthesis showing the major products, carbohydrate and oxygen.

During the day, oxygen is generated. At night, however, the phytoplankton within the pond use up the dissolved oxygen in a process called respiration. During respiration, carbon dioxide is produced and it dissolves into the pond water. Because carbon dioxide is a weak acid, it causes the pond pH levels to drop at night.

\[
\begin{align*}
6\text{O}_2 + \text{C}_6\text{H}_{12}\text{O}_6 & \xrightarrow{\text{nutrients}} 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Energy} \\
\text{Equation 3}
\end{align*}
\]

Equation 3 above illustrates the process of respiration whereby the oxygen and carbohydrate produced during the day is used up as nutrients by algae at night. Carbon dioxide, water and energy are consequently produced as by-products during this process.

Therefore, dissolved oxygen levels in the pond are normally at their highest late in the afternoon and lowest after midnight towards early hours of the morning. Dissolved oxygen levels are reduced on cloudy days due to the reduced intensity of sunlight. The pH levels also fluctuate in a similar fashion to dissolved oxygen. pH is normally being highest late in the afternoon and lowest in the early hours of the morning. This is
because acidic carbon dioxide is used during the day for photosynthesis and carbon dioxide is produced at night from respiration.

The other factors that affect the levels of dissolved oxygen in catfish ponds are water temperature, organic loading and the number and size of fish as well as other aquatic animals in the pond.

5.2.2. Temperature

During the day, pond waters often warm up to temperatures higher than that of the inflowing stream. In the tropics, the temperature ranges generally lie within that for production and the significance of temperature on dissolved oxygen levels is less significant than that of organic loading on dissolved oxygen. Since catfish is a warm water fish, it is preferable to have warm water in the ponds for faster growth. Therefore, pond waters should be managed to maintain warm temperatures, the optimum for catfish being 28-32°C. Do not allow water to continuously flow through the pond because the water temperature in flowing streams is often lower than that in a pond under 'static water' management. Constant flow through of water, therefore results into a reduction of pond water temperatures.

Remember, the lower the pond water temperature, the less food the fish will consume and the slower their growth rate will be. The higher the pond water temperature is, the lower the solubility of dissolved oxygen in water, but this is important to know for hatcheries and for transport of fry.

5.2.3. Organic Loading

When organic matter is added into ponds it results into an increased demand for the available dissolved oxygen and an increased likelihood of pollution. The likelihood and degree to which pollution might occur becomes reduced if the organic matter added can be broken down into smaller less complex particles that are less toxic. This is what is termed as the break-down and assimilation of organic matter.

Oxygen and bacteria are required for the effective break-down and assimilation of organic matter. The oxygen binds with some of the compounds constituting the organic matter to form less toxic compounds. The bacteria on the other hand, are actively involved in breaking down organic matter and transforming it into dissolved waste compounds which when they bind with oxygen become less toxic and polluting. The bacteria
that breakdown wastes in the pond also need the oxygen to live. Therefore, dissolved oxygen in ponds is used up not just by the fish, but by organic matter and other life forms. Water temperature influences the rate at which organic matter is broken down and assimilated; the higher the temperature the faster the process shall be.

Controlling input levels of organic matter therefore becomes a pre-requisite for managing dissolved oxygen levels as well as other water quality parameters within the pond. However, the major inputs into fish production, are organic matter. In the normal course of catfish production, feed is the major organic input into the pond.

During feeding and soon after feeding, the levels of dissolved oxygen in the pond drop. This is because at such moments, the fish need extra oxygen to eat, digest and metabolise the feed that has been given to them. In addition, because the feed is organic matter, as soon as it is enter the water, oxygen is used up as oxidation starts right away. More oxygen is also required for the break-down and assimilation of any left-over feed and the fish faeces. Hence, feeding must be done in a manner that minimises the negative effects of organic loading on water quality. This is effectively done by feeding only the amounts of feed that the fish can consume at each meal and opting to use highly digestible feeds with a high water stability (for more details see sections 6.1. and 6.2.).

For this reason, one should not administer more than 20g of feed per m² per day to catfish ponds receiving no aeration. If one is using a low quality feed that falls apart easily when in water and is not easily digestible by the fish, then he/she should apply even less feed. Remember, once feed has been fed to the fish in a pond, the excess feed cannot be removed. It drops to the bottom of the pond as organic matter. Accumulated wasted feed, subsequently results into pollution instead. Feeding fish by response, is one way of ensuring that the fish are only fed what they can consume.

5.2.4. Ammonia
Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter. Examples of such organic matter include wasted feed, faeces, dead plankton, etc. Fish excrete ammonia across their gills. Ammonia is toxic to fish. High levels in water affect ammonia excretion, blood pH, enzyme systems, and cause gill damage. This is because high levels of ammonia in water impair the
excretion of ammonia from the fish into the water across its gills. Because of the way the gills become affected, the efficiency with which the fish can extract oxygen from the water through their gills also falls. Fish can tolerate 0.01 to 0.05 mg/l of unionised ammonia without a significant negative effect on production as long as levels of dissolved oxygen and water temperature are within the recommended range. They are able to withstand levels of unionised ammonia of up to 0.6 to 2 mg/l for only short periods.

Ammonia occurs in two forms depending on the acidity of the water. The unionised form of ammonia (NH₃) is more dominant when the water is alkaline and the ionised form, ammonium (NH₄⁺) when the water is acidic. In most cases, both forms occur, hence the term Total Ammonia Nitrogen. Total ammonia nitrogen is the combined measure of its two forms, unionised ammonia (NH₃) and ammonium ion (NH₄⁺). The relative occurrence of the either form in water depends on the acidity of the pond water as well as water temperature. The unionised form, ammonia, is the most toxic of the forms of Total Ammonia Nitrogen, to fish. Table 5.2 below illustrates the influence of pH and temperature on the levels of unionised ammonia (NH₃) present in water.

**Table 5.2:** Proportion (%) of Total Ammonia Nitrogen in the Toxic Un-ionised Ammonia (NH₃) form at Different Varying pH and Temperatures

<table>
<thead>
<tr>
<th>pH</th>
<th>NH₃ (%) at Different Temperatures (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>7.0</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>8.0</td>
<td>2</td>
</tr>
<tr>
<td>9.0</td>
<td>21</td>
</tr>
<tr>
<td>10.0</td>
<td>72</td>
</tr>
</tbody>
</table>

Adapted from Schmittou *et al.*, 1998.

In ponds, ammonia can be directly used by *phytoplankton* as a direct nutrient source or is broken down by nitrifying bacteria into toxic nitrite and then nitrate, which is less toxic. This process by which ammonia is broken down through *oxidation* by bacteria in ponds is illustrated in equation 4 below.

\[
\text{NH}_3/\text{NH}_4^{+} + \text{O}_2 \xrightarrow{\text{Nitrosomas bacteria}} \text{NO}_2^{-} + \text{O}_2 \xrightarrow{\text{Nitrobacter bacteria}} \text{NO}_3^{-}
\]  

Equation 4.
Equation 4 shows that oxygen is required to transform ammonia into nitrite then nitrate. The bacteria that help in the process also require oxygen to live. Because additional oxygen is required for this process, the oxygen demand in a pond under such conditions is increased.

High levels of ammonia in water, therefore, indicate either a poor phytoplankton bloom or a nutrient over-load within the pond at levels the normal bacteria in the pond cannot assimilate. When there is a nutrient overload, the amount of ammonia becomes too much for the resident population of nitrifying bacteria to handle. In such cases, the oxygen demand in the pond is also much higher than what the pond can replenish by normal means (i.e. through photosynthesis and air movement). Consequently, dissolved oxygen levels in clarias ponds near carrying capacity are always very low (less than 1 mg/l) and the fish need to get all of their oxygen by gulping air at the pond surface. The pond also starts smelling foul at this stage because of the progressive accumulation of ammonia and other nitrite not completely oxidized. The ability of the pond to sustain production starts to decline because the water quality is poor. The fish consequently become more stressed, stop eating and then stop growing. Subsequently, the FCR increases, diseases may ensue and mortalities occur.

It is at this point, when the water quality of the pond becomes limiting that the pond's carrying capacity is said to be attained. Therefore, in catfish grow-out ponds, production limits are determined by how much dissolved oxygen in the pond water is available for the breakdown and assimilation of ammonia into nitrate by bacteria. So, even though adult catfish can survive in a pond having water devoid of oxygen for a while, there must be a minimum amount of dissolved oxygen in the water (see 5.1. above).

Ammonia levels in ponds are therefore managed by:

1. **Limiting Feeding Rates.** Feed only what the fish can consume at each feeding. When fish are fed as recommended from the same area every day, it is easy to detect overfeeding. This is because the unconsumed feed will accumulate at the pond bottom only in the feeding area. Froth or bubbles, with or without a bad smell, tends appear on the water surface above the feeding area when accumulated wasted feed starts decomposing. The pond bottom in the area where fish feed should be the cleanest and hardest because of their activity (as bottom feeders) around the area when feeding. Therefore, check
the pond bottom for signs of excessive build up of left over feed at least weekly, before you change the ration or when the fish’s response declines and you suspect overfeeding. Check the pond bottom for accumulated left-over feed by:

a. scooping the mud with your hands to find out whether or not there is excess feed and how much feed there is, and

b. by standing in the pond to feel how clean and firm the feeding area is. See Plate 5.1.

2. Controlling Water pH by preventing it Rising Above 9. Water that is relatively hard (alkalinity >60 ppm as CaCO₃) has a better buffering capacity against pH fluctuations. If the waters and soils where the ponds are located are either soft (< 60 ppm and/or acidic (pH < 6), lime the ponds with agricultural lime (CaCO₃) rather than with builders lime (Ca(OH)₂) or quick lime (CaO). This is because agricultural lime is more balanced/stable as a compound as it is made of both a divalent base (CO₃²⁻) and cation (Ca²⁺), which increase both the alkalinity and hardness of the water. Consequently, it does not cause pH spikes as opposed to the builders and quick lime. It also contains carbon (C) as a source of nutrients for phytoplankton.

3. Increase Water Exchange through the Pond only when the Pond Gets near its Carrying Capacity. Water should only be allowed to flow through the pond when the pond’s water quality becomes poor due to waste build up such as when it is approaching carrying capacity. The objective of doing so is to flush out and dilute wastes in the pond as to improve pond water quality. The best way to 'flush' is by reducing the pond water level half way and then refilling it within a half to one day. It is best to drain the water from the bottom when intending to flush. In order to do this, the stand pipe is lowered to the bottom of the pond. Once the water level in the pond has dropped half way, the stand pipe is raised and fresh water is let into the pond to re-fill it. If one cannot flush as recommended due to low water flow on the farm, and low rainfall, then one should not exceed a standing crop of 15 tons/ha. Note that the water leaving the pond is full of nutrients and should be passed through a wetland or agricultural land before re-entering the open waterways.

NOTE: Several farmers think that they must continuously allow small amounts of water to flow through their ponds to maintain good water quality. This is not true for ponds well below carrying capacity. "Routine
water exchange in aquaculture ponds is an example of inefficiency. There are reasons to exchange water in specific instances, notably, to flush out excessive nutrients and plankton and to reduce ammonia concentrations. Daily water exchange usually does not improve water quality in ponds because water temperatures and dissolved oxygen levels in inflowing water are lower than those in 'static water' ponds that have not yet attained their carrying capacity. Pumping costs are also a liability. Ponds are highly efficient in assimilating carbon, nitrogen, and phosphorus inputs not converted to fish flesh, but if water exchange is great, *phytoplankton* is reduced and these nutrients are discharged from ponds before they can be assimilated" (Boyd and Tucker, 1995).

5.2.5. Turbidity

Turbidity is a measure of the transparency of water in the pond. The colour of the water gives an indication of what sort of turbidity it is. If it is brown it is often due to clay and if it is greenish, it is due to *plankton*. Naturally, catfish are bottom dwellers and therefore, more active at the pond bottom. The result is that grow-out catfish ponds tend to have a muddy look, depending on the colour and clay content of the pond's soil. Because of this, light cannot penetrate deep and as the production cycle progresses, only superficial *phytoplankton* can survive in the pond. The pond looks as though there is a green scum that might turn reddish at some moments of the day at the surface of the water. This is nothing to worry about because it is only *phytoplankton* that grows at the surface because that is the only place that the sunlight can reach (see plate 5.2).

5.2.6. Fish Density

The physical crowding of fish at high density ('overcrowding') is not the primary limiting factor in production performance. The primary limiting factors at high fish density in ponds are the low levels of dissolved oxygen and the build up of metabolic wastes. These are indirectly related to fish density and directly related to the quantity and quality of feed required to produce (Schmittou et al., 1998). Therefore, the *biomass* of fish of any given size that can be produced in a pond, is governed by the quality and quantity of feed required to produce it and the subsequent effect of management activities on water quality. Experiments have shown that catfish are actually less stressed when they are more crowded if water quality is maintained. It is also easier to train the fish to feed when they are at high density. If you ever see catfish in a tank of water, note that they are often all together in only a small portion of the tank.
Carrying Capacity

Cattle Farmers:
Assume you had 2 acres of land for raising cow or some other livestock. If all you had was the grass growing naturally on the land to feed the cows would you keep 20 cows to graze on 2 acres of land and expect good production? If your farm of this acreage was located in a semi-arid area like Karamoja – would you even imagine raising 4 cows by tethering especially if it were during the dry season, even if you had 2 acres of land? Why not? Yet someone in the southern part of the country gets some production by tethering this number of animals in the same acreage? If you were to rear 20 cows on 2 acres of land how would you do it? What would be the conditions?

Every cattle farmer knows that grazing 20 cows on 2 acres of land only, where no supplements are given will result in overgrazing, malnutrition for the cows and eventually reduced production. If you were in Karamoja, and the cattle were confined to 2 acres of land, worse still if they were tethered, eventually it would culminate in starvation of the cattle. However, if one had a zero grazing unit, whereby all the pasture, concentrate and water the cows required for production and good health are provided for by the farmer, then one can raise more than 20 cows on the same area, but much of the feed will have to be brought in from the outside.

But again even if one established an excellent zero-grazing unit you would still not be able to have 2,000 animals in 2 acres. Why not? Because each animal requires a minimum amount of space, issues regarding waste disposal and accumulation, etc. etc. For the animals to perform best, they also need a nice clean environment with well ventilated buildings. Otherwise when there is crowding, bad smell (due ammonia from waste), flies - the animals become stressed, develop vices, get sick and no matter what the quality is or amounts of food given to the cows, their yield will be lower than it should be. Coupled with the costs of ensuing treatment, you will be operating at a loss.

Why is this so?
Each production system has its carrying capacity that is dependent upon the ability of that system to provide enough of the right food to the animal. So ranching, with cattle at low density is the most productive and profitable way of rearing livestock in semi-arid areas, unless of course one is supplementing the inputs. In addition, animals perform best when the environmental conditions are good. So, crowding and accumulation of waste result in poor production environments stress and consequently disease.

Likewise, in fish farming, each system has its carrying capacity. If you want a high carrying capacity of your system, then must match up with inputs of the right quality and in the right amounts so that you do not end up with a situation of waste build-up.

Crop Farmers:
For similar reasons, one does not get good yields when crops are planted too close together. Among the reasons for poor yields is due to the rapid depletion of nutrients to the plants. Increasing fertilizer application will allow the farmer to increase the yield; up to a point.
5.3. Managing Ponds with Carrying Capacity in mind and the Implications of Carrying Capacity on Production and Returns

Achieving maximum growth is a common goal in aquaculture. Because production units in fish farming are stocked with young fish, the fish grow at their near maximum rate until food and other environmental (water quality) parameters become limiting. As food availability and/or water quality conditions become limiting, the rate of growth starts slowing down until it gets to the point whereby growth reaches zero and biomass remains stable (Diana, 1997). At this stage, the pond is said to have reached its carrying capacity; because the nutrients and/or water culture conditions in the pond are inadequate to foster growth. The state of carrying capacity has been experienced by many fish farmers in Uganda, often before fish have reached market size. It is easily recognized as being that point when no matter what you do or how long you wait; the fish just remain the same size.

If one is to undertake profitable fish farming, one should never manage production ponds at carrying capacity. Ponds should be harvested before they get to carrying capacity. Ideally, the pond should be harvested when the growth rate of the fish begins to slow, which is called “critical standing crop”. The system must be managed within its limits. Therefore, every fish farmer must understand the dynamics and limits of their production system. Knowing when certain limits come into play makes it possible for the farmer to consciously manage the production unit within the limits of its carrying capacity and to make changes in management that increase the carrying capacity (see Figure 5.1 below).
5.3.1. The Effect of Management Levels on Pond Carrying Capacity

Figure 5.1 illustrates the effect of different management levels on carrying capacity. It also shows which variables become the first limiting factors at each management level.

![Figure 5.1: Level of Intervention versus Standing Crop at Carrying Capacity for African Catfish. (Adapted from Lovshin, 2007)](image)

The reason why there is a limit on how much production can be sustained at the different management levels is because of limits in access to feed, feed quality and water quality. The sections below, discuss how these constraints come into play to limit production at the different management levels and estimates the carrying capacity for each level:

5.3.1.1. Management Level 1 - Unfertilised Pond (100-300kg/ha)

Unfertilised ponds are the lowest, most extensive level of fish production management in ponds. At this level, the amount of food available to the fish for production depends entirely on how much can be produced by natural productivity. The amount of natural productivity depends on the soil fertility, water depth, etc. Ponds at management level 1, should be therefore managed as 'static water'. If water is allowed to continuously flow-through such ponds, the natural food generated gets washed out. At this management level, food quantity is the first limiting production factor. Plankton alone cannot meet the food requirements for more than a few sub-market to table size catfish. Therefore, low stocking rates are advised because the number of fish stocked and the size to which they can be grown must be matched to the amount of food that can be provided naturally by the pond. This level of management is not suitable
for commercial catfish grow-out operations raising fish for table. This is because the cost of pond construction and the value of the land cannot be covered by the value of the fish produced.

5.3.1.2. Management Level 2 - Fertilised Ponds (300 to 3,000 kg/ha)
In fertilised ponds, extra nitrogen, phosphorus, lime and possibly organic material like manure are added to the pond to enhance natural productivity. The ponds are managed as 'static water' to avoid washing away the nutrients added and plankton produced. Such ponds are able to generate much more plankton as food for the fish than unfertilised ponds. Therefore, more kilograms of fish can be sustained in the pond to the point whereby, the fish start consuming the plankton produced at a rate faster than it can be regenerated. At this management level, the amount of plankton that can be produced, is usually the first limiting production factor. Catfish do not consume phytoplankton, but they can consume zooplankton and insects. This level of management is not suitable for commercial catfish grow-out operations for the same reasons as above.

One type of “fertilizer-based” production does often result in rather high catfish production: large amounts of pig manure used as fertilizer/feed. Sometimes, the dead piglets are even thrown into the pond. This is really not fertilizer-based production anymore.

5.3.1.3. Management Level 3 - Supplemental Feed (2,000–6,000 kg/ha)
At this level of management, feed rich in energy is added to supplement the food produced through natural production. Supplementary feeding is often done on combination with fertilisation. The strategy, is to provide an alternative source of energy to the fish, while the plankton provides the fish with their protein and vitamin requirements. Supplementary feeding is often done on combination with fertilisation. However, because the farmer has no physical control over how much plankton as well as how much protein and vitamins the plankton can produce, the first limiting factor to increased production is feed quality.

Supplementary feeds, are often agricultural by-products (e.g. sunflower cake, maize bran, etc.). They may or may not be processed before feeding to the fish. It is recommended that they are processed (e.g. by cooking) before they are fed to the fish in order to improve palatability.
and digestibility. Their water stability (even when cooked on-farm) is poor, and once administered to the fish in the pond, the food easily fall apart, sinking to the pond bottom. This increases organic loading in the pond, with its negative side effects on water quality (see section 5.2.3. above). Hence, when managing such a system, the stocking rates and biomass must be maintained at a level whereby the protein/energy balance from the different feeds is ‘just right’ and the quantity of supplemental feed required to feed the fish adequately does not reach levels that have a negative impact on water quality. The supplemental feeds are often lacking in protein so the catfish often resort to cannibalism early in the production phase, and only a few big fish are found at harvest if the farmer used a too high stocking density.

5.3.1.4. Management Level 4 - Complete Feed (12,000-20,000 kg/ha)

At this level of management, the fish are provided all their nutritional requirements through a nutritionally complete feed pellet. The commercial feed pellets used in this case may either be sinking or floating. The biomass of fish produced in this case is limited by the effect of feed metabolism on water quality. As the amount of feed fed increases, the water quality starts to deteriorate. Dissolved oxygen (D.O.) is usually the first water quality parameter to drop, and become the limiting factor for fish production. Therefore, there is a maximum limit as to how much feed can be safely added to a pond based on the minimum accepted dissolved oxygen level or maximum waste load during a daily diurnal cycle for the species being reared. Static-water ponds fed nutritionally complete diets are therefore, largely managed to ensure that key water quality parameters (dissolved oxygen and ammonia) are maintained within the acceptable range for production.

When feed is administered to a pond, extra oxygen is required by the fish for digestion and by the organisms in the pond for the breakdown and assimilation the feed by-products. That is why oxygen levels drop after feeding and in the event that dissolved oxygen levels in the water are inadequate, water quality deteriorates faster (see section 5.2). Therefore, there is a ‘maximum safe feeding allowance’, based on the lower limits of dissolved oxygen and other water quality parameters (notably ammonia in the case of adult catfish) that the fish being cultured can withstand without comprising production and returns.

For this reason, the carrying capacity of a catfish grow-out pond is greater than that of a tilapia grow-out pond. This is because unlike
tilapia, adult catfish have the capacity to obtain oxygen from the air when dissolved oxygen levels are low in the pond water. Tilapia on the other hand, can only obtain oxygen from the water. More fish biomass and feed can therefore be supported in a catfish pond as opposed to a tilapia pond at this management level, because catfish ‘static water’ grow-out ponds are largely managed based on waste load limits.

The “maximum safe feeding allowance” for ‘static-water’ ponds at management level - 4 is 10g pelleted feed/m²/day for tilapia and 20g pelleted feed /m²/day for catfish ponds. The carrying capacity of tilapia and catfish ponds fed nutritionally-complete feeds in non-aerated ponds ranges is about 10 tons/ha and 18 tons/ha respectively in southern Uganda (see Figure 5.1 above). Practically, this implies that when the fish attain the desired harvest size, the total daily feed requirement for the pond in catfish should not exceed 18-20 g/m²/day (see Box 3 in section 4.3). The reason for this is that, commercial grow-out ponds should never be managed at carrying capacity if they are to be profitably run. They should be harvested before the pond attains its carrying capacity or the biomass in the pond reduced to below carrying capacity if they cannot be completely harvested (see 5.3.3. below).

5.3.1.5. Management Level 5 - Aeration:
At this level of management, fish are fed nutritionally complete feeds but the limiting effect of feed metabolism on dissolved oxygen levels is overcome through aeration. Therefore, a higher biomass can be supported up to the point whereby the accumulation of ammonia in the system, as a result of protein metabolism by the fish, becomes the limiting factor. Fish density and biomass as well as feeding rates are therefore controlled to ensure that ammonia levels are kept within the recommended range. If static pond water management is practiced, the carrying capacity of a tilapia pond receiving mechanical aeration is about the same as that of a catfish pond receiving no aeration (i.e. 18-20 tons/ha). Even though they can breathe air at this time, some aeration does help in catfish ponds because it aids in transforming the toxic ammonia and reduces the build-up of carbon dioxide. However, using a degassing tower will also work very well because it can both aerate and help transform some of the wastes.

5.3.1.6. Management Level 6 - Partial Water Exchange:
At this level of management, the fish are fed nutritionally complete feeds and the limits of feed metabolism on dissolved oxygen levels can be overcome through aeration, while ammonia accumulation is managed.
through partial water exchange to wash out and dilute wastes. More fish can be raised for the parameters given, however, at a higher cost. If aeration is not involved, the water exchange rate must be increased.

In management level 6 the accumulation of wastes is physically managed by removing a proportion of the pond water with high nutrient load and replacing it with good quality water. This results in a reduction of the concentration wastes in the water. At this management level, it is up to the manager to decide how much water and how often water should be exchanged, to achieve the desired levels of water quality. Hence, the upper limits on how much can be produced for this level, depend not just on the feed, but on the water resources the manager has a hand as well as the costs of using this water effectively.

5.3.1.7. Management Level 7 - Flow Through Water Exchange:

At this level of management, the fish must be fed high quality nutritionally complete feeds because there is no other source of nutrients available to the fish. The limits of feed metabolism and feeding on dissolved oxygen levels, ammonia and organic loading, are overcome by continuously allowing good quality water to flow through the pond. This dilutes and washes away wastes before they accumulate to levels that reduce water quality for production. Fish density at this level can be extremely high. However, the amount of fish that can be raised in such a system is limited by what flow rates are required to effectively wash out wastes and replenish water quality. Water flow rates should not exceed the capability of the fish in the system to withstand the currents, as the fish shall instead, start using their energy to withstand the currents rather than for growth.

A water current of 5 meters per minute is generally taken to be the maximum recommended water current for market-sized fish. Flow-through is generally used for tanks or raceways. The width of the tank can be adjusted to keep the water velocity within the acceptable range. Too slow, and wastes accumulate; too fast and the fish expend too much energy in swimming. In these systems, the limiting factor may be the amount of water required or the pumping cost.

In summary, therefore:

1. The inputs one has access to, water resources and markets determine what management system is appropriate.
2. There is no point in adopting the specifications for a given management level of production, if one does not have the right inputs for it. Therefore, if all a farmer has access to are supplementary feeds like maize bran, there is no point in the farmer stocking high rates, because the other parameters are lacking. For example, you will not be able to raise 10 fish/m² to grow-out market size if you do not have aeration, nutritionally complete feed and water quality management tools. Likewise, if all one has is incomplete feed, there is no point in jumping up 2 management levels to increase your carrying capacity using aeration without advancing first by feeding nutritionally complete pellets. This is because the organic loading of the supplementary feed will be too high, and it will become the major limiting production factor in your system. Rise step-by-step.

5.3.2. If Carrying Capacity has been reached in Static Water Ponds, and Complete Diets are Available

If the pond is approaching carrying capacity and there is no immediate market for the fish or one was planning a split program, then the following are the options for managing the situation so as to ensure continued growth:

5.3.2.1. Reduce Fish Density

Before the pond gets to its carrying capacity, the amount of fish in the pond should be reduced if growth is to be sustained. Figure 5.2 and table 5.3 below show how an increase in fish biomass was regained after 195 kg of fish had been harvested from the pond after 180 days. Standing crop had stagnated at about 2,200 kg.

Before carrying capacity, the average growth rate of the fish was 5.1 g/day. Once the pond hit carrying capacity, growth had ceased. After the partial harvest, the total fish biomass in the pond dropped to below 2,256 kg down to 2,111 kg. Because this was less than the carrying capacity of 2,200 kg, fish growth resumed during this interval to 5.6 g/day. (During the times the pond was at carrying capacity the interval average growth rate of the fish between samplings was 2 g growth/day which is extremely low). See details in table 5.3 below.
Figure 5.2: Effect of Carrying Capacity on Growth Trends of African Catfish (Samarieza Mixed Farm, Mukono District).

Table 5.3: Trends in Change of Biomass and Growth Rates of African Catfish at Carrying Capacity

<table>
<thead>
<tr>
<th>Production days</th>
<th>Fish Biomass (kg)</th>
<th>Amount Harvested (kg)</th>
<th>Interval Average Fish Growth (g/day)</th>
<th>Cumulative FCR</th>
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<td>0</td>
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<td>-1.8</td>
<td>2.8</td>
</tr>
<tr>
<td>208</td>
<td>2388</td>
<td>293</td>
<td>1.5</td>
<td>2.2</td>
</tr>
<tr>
<td>283</td>
<td>2338.6</td>
<td>157</td>
<td>-0.2</td>
<td>3.0</td>
</tr>
</tbody>
</table>

(Samarieza Mixed Farm, Mukono District).

It would have been very profitable to harvest weekly as of day 117.
5.3.2.2. **Increasing Water Exchange**

The ability of a pond to produce adequate amounts of dissolved oxygen and assimilate wastes becomes limited in a static water ponds fed with commercial pellets at carrying capacity. Flushing water (partial water exchange), can be a temporal measure to increase the carrying capacity if the ponds cannot be harvested or fish densities cannot immediately reduced significantly. Through flushing, wastes get washed out and diluted. Table 5.4 below shows dissolved oxygen readings and the number of flushings that were required in a catfish grow-out pond fed nutritionally complete commercial sinking pellets under static water management before the pond was at carrying capacity and after carrying capacity. In this case, the pond was only flushed when morning oxygen readings were below 3 mg/l until mid-morning and the water in the pond smelt bad (like rotten eggs). Twenty five (25) % of the water was changed each time. See section 5.2.4. (3) on how best to flush.

**Table 5.4:** Effect of Carrying Capacity on Water Quality and Pond Management Requirements

<table>
<thead>
<tr>
<th>Time (Days)</th>
<th>Morning Dissolved Oxygen Levels (mg/l)</th>
<th>Number of Flushings</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>48</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>61</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>83</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>117</td>
<td>0.1 – 0.3</td>
<td>2</td>
</tr>
<tr>
<td>175</td>
<td>0.1 – 0.3</td>
<td>6</td>
</tr>
<tr>
<td>208</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>283</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>311</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** No oxygen readings were taken where there are no values in the table. Data from Samarieza Mixed Farm, Mukono District.

In catfish grow-out ponds that were 60 cm deep, a carrying capacity of 18 tons/ha was achieved when 80% of the pond water was flushed on a daily basis after the ponds had attained their carrying capacity at 15 tons/ha. Exchanging 80% of the pond water on a daily basis to increase
production can be costly if one has to pump their water (see Chapter 10 for details). Therefore, it is sometimes wiser to:

1. Opt to split the total fish into two ponds before carrying capacity is reached rather than flushing the pond on a daily basis to achieve the targeted production.
2. Opt to construct the pond as recommended so that the average water depth is about 1 meter.

Plan your investment and production accordingly. Preferably find your markets in advance as these will tell you what the cost limits should be for kilogram of fish you produce.

5.3.2.3. Feed Management

Once the ponds are at carrying capacity, no matter how much feed the fish are given to eat, they will not grow because of the limiting production factors within the culture environment. Feeding for growth at this stage only helps worsen the pond's water quality faster.

Remember: in ponds fed nutritionally complete pellets, feed metabolism exerts demands on water quality. Therefore, sell off the fish, or reduce the fish density as soon as possible. If it is not possible to do this immediately, then feed the fish only a maintenance ration, at the rate of 1% body weight per day. The objective of feeding a maintenance ration is:

1. to prevent the fish from losing weight, and
2. to prevent the worsening of the pond's water quality to a point lower than is necessary (see chapter 6.2.2. for more details).

If on the other hand, you are sure to harvest the pond within a couple of days, then you may stop feeding. Catfish lose weight very fast and should not be kept off feed for more than a couple of days unless you are trying to reduce their body fat that accumulated due to poor diet.

5.3.2.4. Aeration

Table 5.4 above illustrates how early morning dissolved oxygen levels were consistently below 3 mg/l once the catfish pond under static water commercial feed management got to its carrying capacity. Adult catfish can survive for longer periods of low dissolved oxygen in water because they are able to gasp in air from the atmosphere unlike tilapia for which the oxygen must be dissolved in water. However, when the oxygen levels are persistently below 3 mg/l their appetite falls. With aeration, one can overcome these low oxygen levels. While aeration in catfish ponds does help overcome low dissolved oxygen levels, the major benefit from
aeration is to cycle the ammonia to nitrate faster and to drive off excessive carbon dioxide.

**Remember**, the catfish ponds cited in the trials required water exchange when the water started smelling foul. In addition, running an aerator requires power for the period when the aeration is required. The use of aeration should be prudent at management levels below 5 because there are cheaper more-cost effective ways of managing oxygen levels in ponds at these levels (see section 5.2. and 5.3.1. above).

### 5.3.2.5. Appropriate Pond Depth

When ponds are deep enough (water depth of on average 1m) there is more water within the pond to dilute waste. This is among the reasons why the *carrying capacity* is higher in ponds whose water depth is about 1 m compared to shallow ponds. Hence, if your ponds are shallow, at the next production cycle endeavor to renovate them so as to ensure that they meet the standards for commercial grow-out ponds. For more details see chapter 3.1. Data from shallow catfish ponds indicated that *carrying capacity* was about 12T/ha (1.2 kg/m²), in ponds averaging 50 cm deep whereas it was over 20 T/ha (2 kg/m²) in ponds of 90 cm average depth. In fact, some people prefer to use kg per cubic meter when describing clarias yields and *carrying capacity*, which makes more sense since dilution of wastes is so much more important than oxygen dynamics for clarias, compared to tilapia.

### 5.3.3. Economic Implications of Carrying Capacity.

The objective of raising fish in grow-out ponds is to produce table fish of a certain size and increase *biomass*. When growth stops, the pond ceases to fulfil this objective. **As carrying capacity** is approached therefore, a production pond is at the *Point of Diminishing Returns*. This means that for each gram of feed added, there is no equivalent increase in fish weight. So essentially, one will be feeding at a loss. Table 5.3 above shows how the interval FCR rises after *carrying capacity* has been attained. Because there is hardly any significant growth at *carrying capacity*, FCRs start rising to above 2. In addition, the costs of maintaining water quality in the pond increase as does the risk of loss through mortality. The break-even costs of production consequently go up, and profit margins start dropping as one approaches *carrying capacity*. Profit margins can quickly become negative at *carrying capacity* (See figure 5.3 below).
NOTE:
Fish growth is plastic. This means that fish does not become irreversibly stunted unless they were starved at a very very young age, like a few days old. Growth in fish stops when the culture conditions are not right, as occurs when the production unit is at carrying capacity. Once the limiting conditions are removed, the fish will continue growing. Therefore, once the carrying capacity in a production unit has been increased, say by water exchange, the fish that stopped growing when the unit was at carrying capacity shall resume growth. This happens even if the fish would have stopped growing for most of a year. Another way to get the fish to begin growing again is to reduce the standing crop by partial harvest or by splitting the population into another pond.

Example: One farmer who had over-stocked at 10 catfish per m\(^2\) pond area and feeding 'home-made' feed had fish that remained at 100 g average weight for an entire year. Some of these fish were removed from the pond and stocked into a newly renovated pond at a rate of 4 fish/m\(^2\) of pond area and the targeted market size of 600 g. The fish were also fed a nutritionally complete commercial feed. In three months their average weight was 437 g. A partial harvest was done to remove larger fish so the others could continue to grow.
Summary Guidelines for Pond Water Quality Management

Once the level of inputs and wastes produced is greater than what the pond can assimilate, water quality starts to deteriorate and the pond’s carrying capacity is reached. Hence, productivity declines.

In order to prevent this situation:

1. Stock based on the pond’s carrying capacity for the specific pond management level to be used and the targeted size at harvest. The carrying capacity depends on:
   a. the type and quality of feed being used,
   b. the size of fish (smaller fish require more feed and have a higher oxygen demand in proportion to their biomass; see feeding chart in appendix 5),
   c. the depth of the pond, up to a point
   d. the quality of water one can maintain in the pond.
2. Feed only what the fish can consume by feeding by response and give only the best feed possible in terms of nutritional quality, digestibility and water stability.
3. Maintain static water during the course of production, only increasing water exchange or flushing when the water quality starts to deteriorate. For example, when the water in the pond starts to smell foul and the fish seem to feed less. “Listen” to the fish.
4. Be careful if you flush the pond; try to avoid a sudden reduction in pond water temperature.

In the event that there are signs of water quality deterioration and/or that the ponds carrying capacity has been attained, then:

1. Reduce the fish density by partial or total harvest, if there is market for the fish.
2. Reduce the amount of feed into the pond (do not exceed 20 g/m²/d, if pond is not being aerated). If it is not possible to reduce densities in the pond, feed only a maintenance ration and not for growth (see Chapter 5 for more details).
3. Increase water exchange or 'flush' the pond in order to dilute wastes.

Note: Fish ponds can be aerated with mechanical aerators. Aeration will result in increased levels of dissolved oxygen, and will help oxidize the ammonia that is a waste product and will subsequently increase the carrying capacity. However, the added benefits in production as a result of aeration vis-à-vis the price obtained locally for table size catfish as well as the investment and running costs for the aerator (notably electricity and fuel) currently does not make economic sense for grow-out ponds in Uganda.
Chapter 5– Water Quality and General Pond Management

a. Enter the feeding area in the pond and with your feet ascertain whether or not the floor is clean and hard. If it is not, there may be waste feed at the bottom. If there is much waste feed, tiny bubbles will often rise as you walk into the feeding zone.

b. Visibly checking the bottom mud for any left-over feed. Smelling it too. If there is a lot of feed decomposing at the bottom, the soil will smell of decomposing feed. Froth or lots of small bubbles on the water surface above the feeding area is an indication that there might be a lot of feed decomposing at the pond bottom.

Plate 5.1: A Farmer Standing in the Feeding Area and Bending to Collect a Sample of Mud
Check the feeding area for any left-over feed at the pond’s bottom at least once every two weeks if you are using sinking feed. Even when you walk into this area, you can feel if the pond bottom is firm meaning the fish are actively eating all the food, or very muddy, meaning that leftover feed is accumulating.
Plate 5.2: Normal Appearance of a Catfish Grow-out in Production
Note, the pond water looks muddy because of the fish’s behaviour. Consequently only surface algae can grow. The algae often are yellowish green in colour; and at very sunny moments of the day, some species of algae turn brownish red.
CHAPTER 6

FEEDS AND FEEDING THE FISH

The objective of feeding fish is to provide the nutritional requirements for good health, optimum growth, optimum yield and minimum waste within reasonable cost so as to optimize profits (Schmittou et al., 1998). Every farmer should be particular about the quality of feed fed to the fish because it is the feed that determines the:

(i) Nutrient loading (and ultimately carrying capacity) in the pond, hence water quality within the culture system
(ii) Fish growth rate,
(iii) Economic viability of the enterprise. 60-70% of variable production costs in a normal production cycle is due to feed.
(iv) Health status of the fish.

6.1. Feed Quality

The quality of feed refers to the nutritional as well as the physical characteristics of the feed that allow it to be consumed and digested by the fish. The feed should contain all the nutrients required by the fish, in the right proportions for good performance (growth and health). The specific nutrient requirements for fish vary with the fish’s size and reproductive state. Table 6.1 below presents the nutritional requirements of catfish. The nutrients within the feed should also be easily accessible to the fish and be digestible.

The physical attributes of the feed determine the degree to which the feed affects water quality and consumption rates by the fish. The physical attributes of a good feed, therefore, are:

1. The ingredients used in the feed should be finely ground. The pellets will have uniform colour and you should not be able to distinguish morsels of maize for example.
2. The feed must be without fines or dust. If too many fines are in the feed, too much will be wasted in the form of a powder that floats on the water surface. Tilapia may eventually consume this powder but larger catfish will not.
3. The pellet should be firm with a water stability of at least 30 minutes. The pellet’s water stability refers to the time it takes for the pellet to completely fall apart in water. Plate 6.1 shows what good pellets should look like. Proper cooking
assures that the starches have gelatinized and this helps hold the pellet together.

4. The pellets should be of uniform size and of correct size so the fish can swallow them. A size of about \( \frac{1}{3} \) the gape of the mouth is advised.

5. The feed should be palatable to the fish with a good taste, smell and feel. Fish will spit out or only slowly consume feed that is not palatable.

One of the major differences between feeding fish and feeding terrestrial animals is that once fish have been fed, the excess feed cannot be retrieved from the water in pond, unless an extruded floating pellet is used, and even this is impractical. Land animals are fed from containers and excess feed can be retrieved, but even land animals have problems when there are too many fines in the feed. The fish in this case will be unable to eat all the feed and obtain all the nutrients it needs for growth as the feed will have disintegrated before they can consume it. This results in poor growth performance and a higher risk of poor water quality. Therefore, the higher the quality of feed that is used, the less wasted feed and the easier it is to manage pond water quality. With better water quality, the greater the pond’s potential carrying capacity.

Catfish do much better when the starches in the feed are adequately cooked, which is more likely to happen with extruded feeds, as opposed to pelleted feeds. However, some pellet mills will cook the ingredients. A farmer can tell by checking the integrity of the pellets.

If the pellets of feed can float, it usually means that the ingredients have been cooked. Floating feed provides an added advantage in that the farmer not only knows when the fish have started feeding, but the farmer will know when the fish have stopped feeding. Even though catfish are thought to feed on the pond’s bottom, they are easily trained to feed wherever the food is, even at the surface. Therefore, it is much easier for the farmer to evaluate feeding response when using a floating feed. However, floating feed often costs more. It is therefore up to the farmer to decide if floating feed is worth the added expense by evaluating fish performance and feed conversion.
### Table 6.1: Basic Nutrients Necessary for African catfish Growth

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Uses</th>
<th>Desired Levels in Diet</th>
</tr>
</thead>
</table>
| **Protein**      | • Provides the proper ratio of amino acids  
                   • Necessary for the building muscle, connective tissues, blood, enzymes, hormones, etc.  
                   • Diets lower than 28% protein result in fatty fish.                                  | 32%                                        |
| **Dietary Energy** | • Not a nutrient in itself, but required to drive chemical reactions for tissue maintenance, growth and activity.  
                   • Too much energy in the feed reduces feed intake and result into fatty fish which reduces dress out yield and shortens shelf-life of frozen products.  
                   • Energy/protein ratios should be balanced for best results.                       | 8.5 – 9.5 Kcal/g protein                   |
| **Fats**         | • Major source of energy for fish.  
                   • Means by which fat soluble nutrients like some vitamins (e.g., E and D) can be absorbed by the body  
                   • Hormones, some sub-cellular components as well as structural elements of the cells.  
                   • Flesh texture and flavour depend on fattiness of the fish  
                   • Fats add flavor to feed and act as an attractant  
                   • Too much fat in feed results into fatty fish and fatty feeds are difficult to pellet and spoil easily. | 4 - 6%; increase as protein level increases |
| **Carbohydrates** | • Poor source of energy for fish. Fish do not digest complex carbohydrates well enough for them to be their major source of energy from feed. But is a cheap filler.  
                   • Carbohydrates are used in fish feeds to provide the binder and expansion characteristics required for pelletizing and extruding. | 20-35%                                     |
| **Fiber**        | • Not really a nutrient. Fish hardly require it and when fiber is high, digestibility of the feed is decreased. Excess fiber will increase pollution of the pond.                                           | < 4%                                       |
| **Minerals and Vitamins** | • Minerals are the inorganic component of the feed  
                   • Wide variety of functions  
                   • Structural component of hard and soft tissues  
                   • Cofactors and/or activators of enzymes  
                   • Osmo-regulators and acid-base balance  
                   • Production of membrane potentials                                                                 | Vitamin C – 50 ppm                          |

Adapted from Robinson, 2006.
6.2. Feeding Fish in Commercial Ponds with Nutritionally-Complete Diets (Pellets)

Obtaining best performance results from fish feed is not dependent on pellet quality alone. Better results are obtained when fish are fed correctly using the right techniques that ensure all fish have access to the feed, the fish's nutritional needs are being met and that no excess feed is fed. Feeding fish correctly means:

(i) giving feed of the correct nutritional quality for the specified age of fish,
(ii) feeding the right feed size for easy consumption,
(iii) feeding the correct amounts,
(iv) feeding at the right time(s) each day.

When fish are fed correctly, growth rates are good and uniform across the population, feed conversion ratios (FCRs) are low and pond water quality is better managed.

6.2.1. Selecting a Feed

When selecting a feed, bear in mind the following:

(i) The species of fish being cultured. Different species have different nutritional requirements. The nutritional requirements for catfish are listed in table 6.1 above.

(ii) The age and size of the fish. Juvenile fish require higher protein in their feed. For grow-out production, a feed with a protein level of 32% is adequate (see feeding chart in appendix 5).

(iii) The quality of Feed being used.

(iv) The anticipated feed conversion (FCR) of the feed. The cost-effectiveness of the feed being used is governed by the FCRs obtained. For commercial grow-out ponds, FCRs should never go above 2.
Choosing the Right Feed

**Poultry Farmers:**
Would you buy maize bran to feed to your layers or broilers raised under a deep litter system? Why would you rather purchase layers mash or broilers mash to feed the birds, since maize bran is cheaper?

The reasons you opt for the correct feed for the right bird are the same reasons you should opt for quality feed for fish. All poultry farmers know that when one compares one’s production when maize bran is fed versus the correct feed, yields are higher when the correct feed is fed and the costs of production are lower when the correct feed is fed, despite the fact that the unit cost of the poultry mash is higher than that of maize bran.

**Dairy Farmers:**
Assume you had a cross-bred cow. If you fed it only dry grass, would you expect the cow to give you 15 litres per day? Definitely not. If it did, you would regard it an absolute miracle straight from heaven. If you provided this same cow with better quality pasture plus legumes, the yield would go up to about 5-7 litres per day. If on the other hand you topped this with some concentrate, you could get up to 10 litres per day or more.

How many of you dairy farmers think it would be a good idea to feed your dairy animals with maize bran instead of dairy meal? Several of you would make such a decision cautiously as the maize bran might destroy the benefits in yield that you would have obtained from giving the right pasture only: milk yield would drop and the cows might fall sick instead. In such situations where you cannot obtain the correct concentrate, most dairy farmers would opt to continue giving the best pasture they have access to and having reduced yields, rather than making losses by feeding disproportionate amounts of maize bran.

So, what feeding maize bran is to catfish, is what feeding dry grass is to milking cows, or feeding maize bran to layers. A dairy farmer who only feeds dry grass knows that because of the nutritional limits of the food he is giving the cow, it is unlikely that the cow will give the same milk yield as one fed on pasture with legumes as well as concentrate, even if they were of the same breed.

Fish are animals too. They need the correct kind of food in the right quantities if they are to give high yields. Fish need the right food to grow, they don’t only need water.

The quality and quantity of feed given an animal is directly affects outputs and returns. The same applies in fish farming. Aquaculture yields, productivity and consequently returns, are directly related to the quality and quantity of food given to the fish.
6.2.2. Estimating the Correct Amount to Feed.

In order to avoid over or under feeding the fish, the right amount of feed must be given each time. The amount of feed to be provided to the fish per day, the feeding rate (ration), is dependent on the fish’s body weight. Fish adjust their food consumption rates to meet their metabolic energy requirements. Therefore, the required ration varies with time during the production cycle depending on:

- the fish’ size (i.e. its average weight)
- the pond water quality - notably in terms of water temperature, dissolved oxygen and pollutant levels.

The amount of feed required per ration can be estimated with the help of a feeding chart and calculated as follows (see appendix 5):

\[ \text{Amount of feed to be fed per day} = \text{average fish size (weight)} \times \text{feed rate (\%)} \times \text{total number of fish in the pond.} \]

Where,

The feed rate is the amount recommended in the feeding chart as a percentage of the fish’s average weight at that time.

\[ \text{Box 4: Examples on Calculating the Daily Feed Ration:} \]

i) If an African catfish of 5 grams requires a ration of 8% of its body weight, how much food should it be given per day?

Amount of feed to be fed per day = 5 grams x 8/100

= 0.4 grams feed per fish per day.

If there are 1000 fish in the pond, then;

= 0.4 g x 1000 fish

= 400 g of feed should be weighed out for the day.

ii) If a catfish fish of 180 g requires a ration of 2.5% of its body weight, how much food should it be given per day?

Amount of feed to be fed per day = 180 grams x 2.5/100

= 4.5 grams feed to be fed per fish per day, so for 1,000 fish = 4,500g

Note:

1. The daily ration calculated above is 4.5 grams for the day but what the fish shall actually consume will depend on the water quality as well as other factors on that day. If, for example, the water temperatures or dissolved oxygen levels drop that day for some reason, the fish will consume less feed. Likewise, if there is a lot of dietary energy in the pellet, the fish may get satisfied sooner than they can consume what was calculated out for them.

2. According to the feeding chart, the fish should be receiving 2 meals a day. Therefore, divide 4.5 grams by 2 = 2.25 grams. Feed about 2.25 grams of feed at each meal. But because water temperatures are normally lower in the mornings, the fish may tend to eat less feed in the morning than they do in the afternoon.

The optimum ration is the one that gives best growth rates, uniform growth and the optimum FCR. This is because at this level of feeding,
there is minimum feed wastage and minimum deterioration of water quality. This is often achieved when fish are maintained at a feeding level just below that of ‘satiation’.

DO NOT overfeed fish because it results in feed wastage, deterioration of water quality and subsequently poor growth. Overfeeding only serves to reduce your profit margin. Likewise, substantial underfeeding results in poor growth and production.

6.2.3. Adjusting the Ration
Feeding rations should be adjusted either weekly or fortnightly depending on the fish’s size. Smaller fish have a much higher metabolic rate and grow at a much faster rate so their rations need to be adjusted more frequently (preferably weekly). Feeding rations can be adjusted with the aid of feeding charts and occasional sampling (at least monthly) to ascertain actual fish sizes and growth rates. At sampling, adjust the ration based on the average weight of the fish obtained, NOT by the weeks in production.

Fish do not feed at the same intensity every day. The amount of food they take in each day depends on the water quality on that day, notably the temperature and any stressors (low DO, high pH, high ammonia, disease, etc.) to which the fish are exposed. Feed rations should, therefore, also be adjusted on a daily basis. Therefore, on rainy cold days one needs not to feed if fish show no interest in feeding as a result of lower water temperatures.

Once ponds are at carrying capacity, stop feeding fish for growth. Feed only a maintenance ration to prevent the fish from losing weight. Therefore, at carrying capacity a feed ration of about 0.5 to 1% body weight (depending on the fish size) is recommended. Feed the smaller ration (0.5% body weight) to adult fish above 600g. Remember, when the pond’s carrying capacity has been reached, fish will not grow regardless of how much you feed them. Feeding more at this time is wasteful. One would rather stop feeding all together if you are sure you will harvest or reduce densities by at least 30% of the pond total biomass within a week. After reducing pond biomass, and water quality conditions improve in the pond, then start giving the full ration once again.

6.2.4. Administering the Feed
The way feed is administered to the fish affects their access to the feed and subsequently plays a great role in influencing growth rates,
uniformity in size and FCRs. When administering the feed, one must therefore aim at ensuring:

1. **Rapid and Positive Consumption of Feed by the Fish.** This is to increase ingestion rates and ensure that pellets do not remain for a long time in the water before they are consumed. Otherwise the pellets will fall apart, and nutrients will leach from the pellet into the water resulting into wastage, and reduced water quality.

2. **Minimal Metabolic Energy Expenditure Associated with Feeding.** Feed the fish the largest particle size it can consume. For example, do not feed adult fish with powdered feed but rather with larger sized pellets. This allows the fish utilise most of the energy they derive from the feed for growth, rather than for obtaining the feed. When fish are feed particles that are too small they end up spending a significant proportion of their energy trying to get enough food. Therefore, a 300 g fish should be fed a 5 mm pellet not a 1 mm pellet. Imagine yourself being asked to pick and eat all the rice for your lunch a grain at a time. It would be easier and more satisfying to consume the rice on the plate within a short time using a spoon.

3. **Ensure all the Fish have Equal Access to the Feed.** When all fish have equal access to feed of good nutritional quality, uniform growth rates are achieved and better FCRs are obtained. It is important to prevent a situation, whereby, only a few fish dominate the access to the feeding area. When only a few fish dominate the feeding area, the fish that can get to the feed grow much larger and start predating upon the smaller fish. In such a case, there will be a few jumper fish plus several small fish. Consequently overall survival rates and FCRs at harvest become negatively affected.

Feed can be offered to fish in ponds by one of the several ways:

a. By broadcasting (floating and sinking pellets). Slow broadcasting of pellets is the recommended way for administering pellets to catfish grow-out ponds (See Plate 6.2a and for details see section 4.2.5 below).

b. Via feeders (floating and sinking pellets).

c. Applied within feeding rings (floating feeds - especially for juveniles in ponds)
When deciding what feeding technique to adopt, the following should be taken into account:

1. How much feed should be fed per day per fish (*ration size*)?
2. How many times a day the fish should be fed (i.e. the feeding *frequency*)?
3. When the feeding times should be? The amount of feed consumed and the rate at which fish can metabolise it depends on water quality. Therefore, avoid feeding early in the morning when water temperatures and oxygen levels are usually at their lowest.
4. How you intend to administer the feed (i.e., the feeding technique)?
5. Labour availability and costs.

### 6.2.5. Feeding Frequency

The *feeding frequency* is the number of times fish in a pond are fed in a day. The feeding frequency affects the efficiency of feed utilisation (i.e. the *FCR*) so it is important to establish the optimal frequency of feeding so as to attain the best possible (optimal) *FCR* and uniform sizes of fish.

The following should be taken into account, when deciding how frequently fish should be fed each day:

1. For optimum growth and feed conversion, each feeding should be about 1% body weight. However, it is expensive in terms of labour to feed 4 or 5 times per day. In grow-out ponds, feeding 2 or 3 times a day is adequate.
2. Proper feeding frequencies reduce starvation and result into more uniform sizes.
3. Juvenile catfish need to be fed more frequently than adults, because they have higher metabolic rates and their stomachs are too small to hold all the feed they require for a day (see feeding chart in appendix 5).
4. Catfish from 400 g can be fed once a day, because at this size the stomach can hold enough food for the day. At this stage, feeding all the fish at the same time once a day, results into more uniform growth rates because the greedy ones will still be full when there is still food around in the pond. This provides a good chance for the smaller fish to come and feed, hence, they also grow.
5. The feed administered at a meal should be consumed within the first 15 minutes of the feeding if you are using floating feed. If it is not, reduce the amount given to match how much can actually be consumed. This is a bit tricky with sinking feed but it is possible.
6.2.6. Feeding Response

It is extremely important to feed fish in ponds by response, because:

1. It enables the farmer to feed the fish based on their actual needs at each meal. Therefore, the likelihood of overfeeding or underfeeding is reduced to a minimum.

2. It enables the farmer visually assess the number of fish in the pond, and their growth on a daily basis without actually having to physically handle the fish. The only time a farmer can see most of the fish in the pond in one mass, is during the course of feeding (see Plate 6.2b). Hence, feeding by response also provides another avenue for inventory control.

3. When water quality conditions in the pond are poor, or fish are sick, their first response is to go off feed. When fish are fed by response, it becomes easy to detect when they have lost their appetite. Therefore problems can be detected sooner, and remedial measures effected promptly before it is too late. The fishes feeding response, is therefore, the first indicator of the fishes well being.

The fish’s feeding response depends on the:

1. **Suitability of the Feed.** The feed’s appearance, smell, texture/feel and taste also influence the fish’s appetite. The more palatable the feed is, the better the feed response should be.

2. **Culture (Water) Environment.** The most important water quality parameters that affect feeding response in ponds are water temperature and dissolved oxygen. The warmer the water and more dissolved oxygen it has, the more active fish will be and the better their feed consumption and FCR.

3. **Other Stressors,** such as pollutants in water, other water quality variables (notably of ammonia and pH), handling and social interactions also affect the fish’s appetite. When fish are stressed, their appetite drops quickly.

### 6.2.6.1. Assessing Feeding Response

The attention paid by the farmer or person feeding is extremely important in assessing how much the fish actually need to be fed at each meal, or that day. In order to make this assessment, the following should be noted by the farmer during feeding:

1. How fast the fish moved towards the feed and how this reaction/behaviour compares with that at previous feedings?
2. Whether or not the fish are interested in the feed?
3. What the colour of the pond water is prior to feeding?
4. What proportion of the fish comes to the feed?
5. What the weather was a few days before, and on that day? Is (was) it rainy, cold or hot?

Therefore, the farmer must always stay around during feeding to watch how the fish feed every single day. Simply calculating and feeding the amount prescribed by the feeding chart results into wastage, high FCRs and poorer water quality. Feeding based on calculations only, is therefore “dumping” the feed, or "feeding the pond"; not feeding the fish.

6.2.6.2. Criteria for Judging Feeding Response
The following is a description of the criteria used to judge the fishes feeding response:

E - Excellent - Fish are very active and come to feed immediately. The feed administered is all consumed by the fish within 5 to at most 10 minutes of feeding.

G - Good - Fish are less active and come to feed over a longer duration. Feed gets consumed in about 15 to 20 minutes.

F - Fair - Fish are sluggish but do consume about three quarters of the feed. However, they do so in over more than 30 minutes.

P - Poor - When feed is applied, fish do not come to feed. More than three quarters of the feed administered is left over.

NOTE: The grading criteria listed above are subjective. Therefore, it is upon each farmer or the person feeding, to study the fish and their feeding behaviour. As much as possible, the same person should feed the fish on a daily basis. Likewise, the person who feeds the fish should be the one who keeps the daily feeding records, not someone else.

6.2.6.3. Training Fish to Feed by Response
Fish should be trained to come up, and get their feed at the water surface. In order to do this, the following steps should be followed when fish are fed by the slow broadcasting technique:

a. Administer the feed at the same place in the pond and at about the same time every day. This gets the fish into the habit of being in a certain area of the pond at feeding time. If the fish do not come to the area to feed initially, do not add any more feed until they learn to come to the assigned feeding area. It may take
up to a week to train fish to come and feed from the same area and learn their feeding times. Do not worry if in the mean time they do not get much. One may stomp at the edge of the pond, to call the fish at feeding time before administering the feed to them.

b. Broadcast a handful or plate full of the feed once most of the fish have collected at the feeding area. If the fish come out to get the feed and immediately consume the 'tester', then the rest of the feed may be added. However, do not trickle the rest of the feed into the pond bit-by-bit. Rather, slowly broadcast large scoopfuls or bucketfuls at a time, until the fish's response starts to slow and the fish show no more interest in coming back for more feed. Weigh any leftover feed and keep it for the next meal.

By training fish to feed in this way, one is deliberately creating competition for food. The fish soon realise that if they do not come to feed at meal times, then they will not have food until the next meal time. Therefore, the fish actively compete to get to the feed at meal times and eat as much as they can, as fast as they can. Because all the fish eat at the same time, growth rates become more uniform and FCRs consequently improve. The effect is similar to that obtained when several children are made to sit around, and eat from the same plate.

6.2.7. When Not to Feed Fish

1. The Feeding Response is Poor. When the fish show a poor feeding response, it is normally for a reason. The water quality may have changed. For example, on a cold wet day, the pond water temperature may have dropped. Therefore, do not add more food than the fish are interested in consuming. Rather, find out the cause of the poor response and if it is due to something you can address, then correct it.

2. They are Feeling Unwell. When fish are sick, they go off feed. If you insist on feeding them, they still will not eat. The feed administered will instead accumulate at the bottom of the pond, and cause the water quality to drop. No positive returns accrue from wasted feed. Instead losses accrue due to reduced water quality, higher FCRs and the lost income from the wasted feed.

3. At least Two Days before Harvest and Transportation. This is to allow them to empty their guts before harvest and
transportation. In so doing, water quality in transport containers can be better maintained and stress levels during transportation reduced. The other objective is to improve quality of the harvested product for the market.

4. The Afternoon before Sampling and on the Sampling Day before Sampling. Fish should not be fed the afternoon before sampling for the same reason as above. Also, do not feed them on the actual day of sampling especially before they are sampled. This is because they will be subjected a lot to stress from physical handling during seining, weighing and counting. In addition, the act of passing a seine through the pond has a temporal negative effect on water quality because of the mixing of the top and bottom pond water. The bottom water is often of poorer quality.

Young fish still being fed more than once a day, may be fed that day after sampling at their normal feeding time. Adults fed once a day should be fed next the day after. Because of the stressors the fish will have been exposed to at sampling, their feeding response is likely to be poorer for up to two days after sampling or partial harvests. The fish will still be recovering from the handling stress. Therefore, do not insist on giving the fish their full ration, if they show no interest in feeding after sampling or partial harvests. Only give the full ration when their response picks up.

5. When Treatments are applied to the Pond. When some treatments like formalin are applied to the pond, the fish get stressed because the water quality within the pond will have temporarily been altered. Their appetite subsequently drops. It is best to allow the water quality to improve and when it does, so will the fishes feeding response.

6. When Water Temperatures are Low on Rainy Days. After a series of rainy days if the water temperatures drop below 22 °C, the fish are unlikely to be interested in feeding. Therefore, do not feed.

6.3. Evaluating Feed Performance
Feed, is the input with the greatest influence on water quality during production. Feed is also the input whose expenditure line is the largest during the course of production. Feed performance alone, can therefore single handily make or break one’s business. Therefore, it is extremely
important to closely monitor the performance of feeding during the course of production, in feed-based systems.

### 6.3.1. Feed Records

Records about feed usage should indicate:
1. the type of feed(s) administered,
2. the amount of feed given each day,
3. the feeding response at each feeding,

Records will help assess cost-effectiveness of the feeding program.

Figure 9.3 in section 9.2.1. explains how to fill the daily feed sheet while figure 9.4 in the same section gives examples of two different ways of filling the feed record sheet.

### 6.3.2. Feed Conversion Ratio (FCR)

The *Feed Conversion Ratio* (FCR) is the amount of food required to produce a unit of fish (see equation 6 below). It is an indicator of the:

i. performance of a feed,
ii. performance of the person feeding the fish and the fishes health
iii. cost-effectiveness of using a particular feed.

\[
\text{FCR} = \frac{\text{total amount of food given (kg)}}{\text{total amount of fish produced (kg)}}
\]

**Equation 6**

**Box 5: Example on How to Calculate FCR and use FCR to Assess Returns to Feed**

i) If at the end of a production cycle, a total of 150 kg of fish are harvested from a pond and a total of 200 kg of feed was fed to the fish during production, how much feed was required (used) to produce each kilogram of fish harvested? The FCR will be:

\[
= \frac{200 \text{ kg (total amount of feed fed during production)}}{150 \text{ kg fish harvested} - 10 \text{ kg fish stocked}} = 1.4
\]

This means a total of 1.4 kg of feed was used to produce each kilogram of fish.

ii) If each kilogram of feed cost USh.500/=, how much did it cost to produce 1 kg of fish?

\[
= \text{Amount of feed required to produce 1 kg of fish (FCR)} \times \text{Unit Cost of feed (USh.s.)}
= 1.4 \text{ kg} \times \text{USh.s. 500/} = \text{USh.s. 700/}
\]

USh.700/= was spent on the feed to produce each kg of fish.
In grow-out operations, a good FCR should be between 1.5 and 2 when using the pellets currently available on the market. The FCR should never be above 2. Having it equal to 2 means 2 kg of feed is used to produce a kilogram of fish. A feed conversion above 2 is poor and arises when:

i) Poor quality feed is fed. This occurs when feed is of poor nutritional value or the pellet is of poor physical quality.

ii) The feed (size or nutritional quality) given is not suitable for the age of fish being grown. For example, the pellet may either be too big or too small, contain nutrients in the wrong proportions, etc.

iii) The culture conditions are stressful to the fish. For example, if dissolved oxygen levels are continuously below 1 mg/l and/or ammonia levels are high (>20 mg/l), as commonly occurs when ponds have attained their carrying capacity.

iv) Fish are ‘over-fed’.

v) Survival rates at harvest are low. Low survival rates may arise as a result of stocking small sizes, poor handling at stocking, predation, etc.

vi) Feeding for growth when the pond is at its carrying capacity.

6.3.3. How to Assess the Cost-Effectiveness of a Feed

When evaluating the cost-effectiveness of a particular feed, the FCR of that feed and its unit cost should be taken into account simultaneously and not independently of each other. Using the cheapest feed available, more often than not, does not translate into the lowest cost to produce a kilogram of fish (see table 6.2 below).

Table 6.2: Example showing what it Actually Costs to Produce a Kilogram of Fish using Different Feeds

<table>
<thead>
<tr>
<th>Maize bran</th>
<th>Farm mixed fish feed</th>
<th>Complete diet/pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Cost of feed/kg</td>
<td>400/=</td>
<td>515/=</td>
</tr>
<tr>
<td>FCR of the feed</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Amount of feed required to produce 1 kg of fish</td>
<td>9 kg</td>
<td>5 kg</td>
</tr>
<tr>
<td>Total Cost (USh.) of feed used to produce a kilo of fish</td>
<td>= 9 kg bran x USh. 400/= = 3,600/=</td>
<td>= 5 kg feed x USh. 600/= = 2,575/=</td>
</tr>
</tbody>
</table>
Chapter 6 – Feeds and Feeding the Fish

Note: (i) Costs of all feeds based on actual market prices at the end of November, 2008
(ii) Farmer's feed mixture – 60% maize bran, 15% fish meal, 15% sunflower cake and
10% cassava flour.

The lower the FCR, the lower the amount of feed used to produce a kilogram of fish. Therefore, the feed which gives the lowest FCR, even though it might be more costly, is often the one that gives the lowest cost of production.

6.4. Managing FCRs

Ensuring that your FCR remains within an economic range (i.e. of not more than 2 at harvest), is extremely important when raising fish using 'feed-based' technologies. An FCR greater than 2, more often than not results in losses. This is because about 70% of one's operational costs are spent on buying feed for the fish. So any slight drop in the FCR, results in a significant increase of one's profit margins,(Table 6.3).

The FCR obtained is simultaneously influenced by the quality of feed given, the fish themselves, pond water quality and feeding management. These factors act together and determine the fish's appetite, as well as how much of the feed eaten is actually digested and used for growth. Hence, they collectively determine what the FCR shall be at any given time (see figure 6.1 below). All four factors must perform optimally to get an optimum FCR. A lapse in any one of four results in higher FCRs.

Table 6.3: Proportionate Change in Cost Structure for Major Production Inputs over the Course of Production from a Catfish Mono-Culture Pond – Static Water Pond Management, Fed Nutritionally Complete Pellets. Data from Samarieza Fish Farm, Mukono.

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>% Total Variable Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fingerlings</td>
</tr>
<tr>
<td>0</td>
<td>98.7</td>
</tr>
<tr>
<td>18</td>
<td>91.5</td>
</tr>
<tr>
<td>28</td>
<td>81.4</td>
</tr>
<tr>
<td>48</td>
<td>66.7</td>
</tr>
<tr>
<td>61</td>
<td>55.1</td>
</tr>
<tr>
<td>83</td>
<td>46.1</td>
</tr>
<tr>
<td>117</td>
<td>38.1</td>
</tr>
<tr>
<td>175</td>
<td>32.0</td>
</tr>
<tr>
<td>208</td>
<td>28.9</td>
</tr>
<tr>
<td>283</td>
<td>23.6</td>
</tr>
<tr>
<td>311</td>
<td>22.8</td>
</tr>
</tbody>
</table>
Table 6.3 illustrates how, by harvest time, expenses on feed shall be about 70% of Total Variable Costs. It is therefore important to use feed as efficiently as possible in order to optimize returns.

**Figure 6.1**: Factors Affecting the FCR

Therefore:

1. **The Person Feeding** is the most important person on the farm. He or she must be in position to:
   a. Train fish to the fish feed based on response.
   b. Keep track of and evaluate fish feeding response as well as fish performance through actual observation and keeping of records (i.e., with quantitative as well as qualitative information).
   c. Keep track of fish numbers and sizes in the various production units during the course of production.
   d. Deduce correctly from the pond and feeding records as well as the fish's feeding behaviour, what the next course of action should be (e.g. what type of feed to give, how much feed to give, whether or not to adjust or withhold feeding, how best to administer the feed, what pond/water management details need adjusting, etc.).

   If the person feeding cannot do this, then it is not worth spending money on commercial feeds as you will end up losing money instead.

2. **The Feed**
   a. **Quality** (both physical and nutritional). Having a well made pellet of the correct size and of the right nutrient value for the size of fish being raised, is extremely important. Pellet integrity is also important.
   b. **Quantity**. It is important that the right amounts are fed.
3. **The Fish**
   a. **The species being raised.** For example, tilapia *fingerlings* will perform better than catfish *fingerlings* in an earthen pond receiving only fertiliser as an input.
   b. **The size of fish.** Fry require a higher protein level in their feed as well as a smaller feed pellet compared to adult fish.
   c. **Quality of seed stocked.** For example, was the fish *stressed at stocking*? Was it of the correct *stocking size* for the unit and intention for which it is being raised? For example, catfish grow-out ponds should be *stocked* with fish of not less than 5 g but preferably with fish of 10 g and above. *Nursery ponds* on the other hand, are managed to ensure survival young fry and can therefore be *stocked* with fish of 1-5 g.

4. **The Water Quality within the Production Pond**, notably:
   a. the water temperature,
   b. levels of oxygen,
   c. levels of ammonia, pH and other pollutants in water.

6.5. **On-Farm Feed Handling and Storage**
   The quality of a feed begins to deteriorate steadily after manufacture. The rate and magnitude of decline can significantly be slowed, through proper feed handling and storage at the farm. The following are recommended guidelines for handling and storing dry pelleted fish feed from time of purchase.

1. Check the labels and buy the freshest feed in the store. Feed pelleted within the past 4 weeks often meets the nutritional and physical standards stated on the label. Feed degradation can include loss of vitamins, especially vitamin C, and an increase in mold, etc.

2. Purchase only the quantity of feed that will be consumed within 4 to 6 weeks. Remember, the longer the feed is in storage, the lower its nutritional quality will be with time.

3. During transportation and handling, protect the feed from moisture, heat and direct sunlight. Heat and sunlight directly destroy feed nutrients like vitamins.

4. Store the feed in a cool, shaded, dry and well ventilated room. White, wooden buildings with reflective metal roofs are excellent for storing feed. Warm, moist and stagnant air enhances mold growth and attracts insects.
5. Do not stack bags on feed directly against a wall or on a concrete floor. Stack them on top of pallets off the walls of the building to prevent moisture coming in contact with the bags (see Plate 6.3a).

6. Protect the feed from rodents, bats, chickens and other animals. The feed can be stored in cages made of coffee wire mesh to keep off such animals (See Plate 6.3b).

7. Try to minimize insect contact and infestation.

8. Do not use pesticides or other toxic materials near the feeds.

9. Do not keep feed that has been molded or spoiled. Learn what the normal colour, smell and taste of the feed you use is. If the feed looks gray, blue or green in color; has a sour, musty or mildew odour (smell); or has been wet and has clusters of fused pellets - do not use it (Plate 6.4b).

**NOTE:** If you are feeding during the rain and the feed gets wet, feed all that wet feed that day or as soon as possible. Do not store wet feed, as it will get moldy.
Summary Guidelines for Feeding Formulated Pellets to Catfish

Besides the quality of the fish stocked, feed is the most important input in commercial catfish pond production because:

1. Feed is the highest proportion of operational costs and, therefore, the profitability of the operation depends largely on the performance of a feed (i.e. FCR). Remember, the aim is to convert the feed into fish to sell.

2. Pond production performance is attributable to the feed quality and the feeding technique.

3. Using a feeding technique based on feeding response is the best way a farmer can keep track of the:
   i. number and size of fish in the pond between samplings and at harvest
   ii. health status of the fish

In order to get the best out of a feed, one must:

1. Construct and prepare ponds for stocking as recommended in Chapter 3.

2. Stock the ponds based on their pond's carrying capacity in relation to targeted harvest size (see Chapter 4).

3. Ensure best water quality (see Chapter 5).

4. Feed the best quality feed available and aim for an FCR less than 2 as follows:
   a. Feed the right feed correctly based on the fish's feeding requirements and response.
   b. Be conservative when using feed because it costs money.
   c. The feed used must match the ponds inventory. Know the numbers and sizes of fish in the pond. Adopting a single batch system of management (stock one size and harvest all before restocking pond) allows better knowledge of what is actually in the pond and the population's size distribution. This is extremely important in catfish production because the larger fish will predate upon the small fish.
   d. Avoid overfeeding. One would rather keep fish slightly hungry than overfed.
   e. Avoid swings in feed input i.e. impromptu or haphazard feeding. Other than increasing FCRs such feeding results in increased size variation within the population which in turn results into increased cannibalism and lower survival rates. Catfish lose weight fast when not fed for a while.
   f. Base your feeding rate on the fish's feeding response using the feeding chart only as a guide. Feeding by response means the person feeding MUST take time to feed and observe how the fish are feeding.

5. Keep and regularly evaluate pond and feeding records. The person responsible for feeding should keep the daily feeding records. Adjust pond management and feeding based on the information derived from the records.

6. Harvest the production ponds before they reach carrying capacity. In the event that it is not possible to harvest the pond or reduce the fish density,
   i. ‘flush’ water through the pond before it gets to carrying capacity when there are signs of water quality deterioration, and
   ii. feed only a maintenance ration about 0.5% to 1% body weight per day.
Good fish feed pellets maintain their integrity in water for several hours. This is what is referred to as the feed's 'water stability'. A poor quality pellet disintegrates rapidly in water.

If you were feeding small catfish, you would want all of the pieces of feed to be small so the fish would not have to wait for them to dissolve before eating. Many feed companies have trouble adjusting their cutters on the pellet mill and do not make uniform-sized pellets. This will result in wasted feed.

Plate 6.1: Pellet Quality - Water Stability and Uniformity
a. A Farmer Feeding by Slow Broadcasting of Pellets.
   Slow broadcasting is the recommended way for administering pellets to catfish grow-out ponds. Do not trickle the feed in.

b. A Good Feeding Response.
   Note that one can see the fish as they come up to feed, if they have been properly trained. You do not have to be seated.

Plate 6.2: Feeding Fish by Response

a. Bags of Feed in Store.
   On top of pallets and off the walls of the building to prevent moisture coming in contact with the bags. This provides protection against rodents.

b. Feed Cage.
   A simple cage made of timber and coffee wire mesh all around to keep out vermin.

Plate 6.3: Alternatives for Proper Storage of Feed
a. Good Pellets.
Note the uniform colour and with no powdery substance

b. Moldy Pellets.
Note (i) the colour of pellets is not uniform, (ii) the powdery substance that remains on the hand and (iii) the holes in the pellets. The whitish tinge and powdery substance that remains on the hand are due to mold. The holes are due to insects.

Plate 6.4: Pellet Quality: Identifying Moldy Pellets
The objective of every activity where fish are handled is to effectively and efficiently accomplish the task with the minimum amount of stress to the fish. Effectiveness, efficiency and minimum stress are interrelated. Therefore, before undertaking any activity that requires handling of fish:

1. plan when and what will be required,
2. prepare the materials, including all personnel beforehand,
3. execute the procedure and evaluate the results,
4. improve upon the process each time.

7.1. Handling Fish

Stress can be avoided or minimized at handling by observing the following:-

1. Only handle fish that have not been fed for at least 24 hours.
2. Ensure fish are always in water with adequate dissolved oxygen (ideally about 5 mg/l). Only take fish out of water when necessary (e.g., during weighing) and for not more than a few seconds at each time.
3. Work with fish when water temperatures are warm, preferably above 24 °C. The optimum water temperature for raising the African catfish is between 26 °C and 28 °C. Handling fish in cold water pre-disposes them to stress and disease. Unlike many places were the African catfish is found, southern and western Uganda have cooler than optimal temperatures, especially in early morning and at night.
4. Stock fish when water temperatures are preferably above 25 °C.
5. Do not expose fish to temperature differences of more than 3 °C without adequate acclimation.
6. Avoid exposing catfish adults to conditions of low dissolved oxygen without access to the water surface. For juveniles below 100g, the dissolved oxygen levels should not go below 4 mg/l for long periods and/or several days in a row.
7. Avoid exposing fish to chemicals and pollutants. If you must treat fish, do so using only approved treatments and only as prescribed. The only exception is with salt for reducing stress on the fish during handling and transport (use 0.5 % salt solution).
8. Avoid holding fish temporarily in tanks and similar strict confinement for longer than necessary. If you must, use aeration or flowing water. Hold adult catfish preferably in containers with a wide open surface area so that in the event the dissolved oxygen levels drop, they can easily come up to the surface to gulp air.

7.2. Sampling

Sampling is the temporary removal of fish from the pond. The major reasons for sampling are to:

1. monitor growth and general performance,
2. re-calculate feed requirements,
3. determine when fish are ready for market
4. determine if the pond has reached its carrying capacity
5. assess the health of the fish

After making the observations required, fish are returned to the pond. Sampling is a stressful process for the fish because they are crowded, physically handled and removed from water during the process. Handling can lead to physical rubbing of the fish's body causing the removal of the surface mucus layer and injuries which make it easier for infectious agents (for example bacteria or parasites) to enter the fish's body through the skin. Therefore, sampling should only be done when necessary and in the least stressful manner. Grow-out ponds should be sampled once a month in order to monitor growth and re-calculate feed requirements.

7.2.1. How Best to Sample

The sample taken should be random and truly representative of the rest of the population. If it is not, then the sampling information will not give an accurate picture of the status fish population in the pond at that time. This could lead to over or underfeeding.

During sampling fish become stressed because they are physically handled, suddenly confined into a small space and removed from water. In order to reduce the levels of stress one must:

a. Reduce the time the fish are exposed to the stressors mentioned. Execute the task at hand fast and efficiently.

b. Only sample a small part of the pond; do not seine the entire pond.
c. Keep the fish in water all the time or as much as possible. The only time they should be out of water is when the fish basket is lifted to the weighing scale (see Plate 7.2c).

If fish are stressed during sampling, mortalities can occur for up to three days after sampling.

7.2.1.1. The Day Before the Sampling.

1. Plan and obtain the requirements for sampling in advance. This includes setting the sampling day and determining in advance what materials and personnel will be required. The tools required for sampling are:
   i. Seine net (preferably one with a bag) with the proper mesh size
   ii. Fish baskets
   iii. ‘Dead’ men (about 4)
   iv. Weighing balance or scale
   v. Large basin or tub (See Plate 7.1)

2. Do not feed fish the afternoon of the day before and before sampling on the day of sampling. Adult catfish fed once a day, should not be fed the day before sampling. This is to ensure that their guts are empty during sampling. Physically handling fish with full stomach is stressful to the fish and results into mortality.

7.2.1.2. On Sampling Day.

1. Set everything needed by the pond side first, personnel inclusive. Everyone should also know before embarking on the exercise, exactly what they are going to do. Practice makes perfect and saves fish.

2. Seine the pond when the water quality is optimal. When pond dissolved oxygen levels are picking up (from 4 mg/l and above) and water temperatures are not too low or too high (from 24°C to 28°C).

3. Seine about a quarter of the pond by ‘cutting off a corner with the seine. Keep the fish held in the bag while they are waiting their turn to be weighed. Avoid crowding the fish too much (see Plate 7.2b). When catfish are crowded, the fish at the bottom cannot get access to the water’s surface to gulp in air in the event that dissolved oxygen levels drop too low. The fish may consequently drown.
4. All the fish caught in the bag should be weighed and counted. It is important to do so, in order to avoid bias. When one hand-picks fish from a container, one tends picks out the larger (i.e. they are easier to see) fish. Also, check their general body condition (e.g., look for wounds, discoloration, etc.). It is sufficient in grow-out ponds to only obtain batch weights. It is extremely stressful to the fish and time consuming to weigh each fish individually on the farm.

5. Weigh a basket of fish at a time. Do not overload baskets with fish as the fish at the bottom become stressed by the pressure of those above when the fish basket is lifted out of the water. Load not more than two thirds of a basketful at a time. After weighing the fish, return the basket to the water and count out the fish from the basket as you gently let them swim out. DO NOT PHYSICALLY HANDLE OR THROW the fish back into the pond as you count, but let them back into the water gently. It is extremely traumatic for fish when thrown into the ponds. Minimize touching the fish as this rubs off their protective layer of mucus (See Plate 7.2d).

6. Obtain the total batch weight and count of fish caught. From these data, calculate the average weight (total fish weight of sample/total number in sample). Do not measure and weigh fish individually, unless there is some specific need for that information and the fish are expendable. For aquaculture production, batch weights are sufficient because it is the weight of fish that is sold. Remember that after sampling, the fish should still be in good condition to survive and continue growing.

7. From the feeding records, total up how much feed the fish consumed from the last sampling and calculate the FCR for that interval as well as the overall FCR from stocking. This provides an indication of feed performance and allows any management adjustments necessary to ensure that the overall FCR does not go above 2 at the final harvest.

7.2.2. When Not to Sample Ponds

Do not sample ponds when:

1. Fish are sick and show signs of extreme stress.
2. When there is lightning during a rain-storm. This is because if the lightning strikes the pond, the people in the pond can be electrocuted.
3. If it has just rained and there has been a lot of muddy water run-off into the pond. (catfish will already be stressed from this)

4. When the water quality is poor, such as when:
   a. there is a bad smell from the pond,
   b. one notices fish gasping for air,
   c. the water temperatures are 22 °C or lower at the time you intend to sample, or above 34 °C.
   d. low dissolved oxygen levels of less than 4 ppm beyond mid-morning.

   In such situations, one should postpone the sampling until when the water quality and fish's condition have improved.

7.3. Harvesting

When fish are removed from the pond and not returned, they have been harvested. Fish are normally harvested for the following reasons:

1. sale and/or consumption.
2. transfer to other ponds,
3. mortalities are also regarded as “harvest”, in the pond record because they are fish removed. They should be noted as mortality.

As much as possible, harvest based on your marketing plan. The pond should finally be harvested before it gets to its carrying capacity.

7.3.1. How to Harvest Ponds

Ponds may be harvested with a seine net or by draining. Draining the pond marks the end of a production cycle because all the water from the pond will have been removed.

When a pond is to be harvested completely, it is better to pass a seine two or three times before completely draining it in order to reduce the number of fish in the pond. This may be done on the same day or over a period of time. It is much easier to harvest a pond by seining rather than by draining and picking up the fish from the mud.

Once the number of fish caught in the successive seines drops to about a quarter of the estimated stock, the water level in the pond can be reduced to about half-way for the last seining. After this, drain the pond completely and gather the fish using scoop nets. During drainage ensure that the screen on the outlet (as well as inlet pipe) is properly fixed to
prevent fish going out of the pond, unless you intend to use an exterior harvest basin. Make sure there is someone around to watch out for birds and other potential predators (including man).

Because seine nets for grow-out ponds are costly, one may have to hire a net for harvesting and sampling. Therefore, the number of times a pond has to be seined before it is completely harvested matters as it has a bearing on one’s operational costs, and consequently returns. One should also endeavor to minimize the amount of labour required during sampling and harvesting. Therefore, it is better to use a seine with a bag (i.e. the recommended commercial pond seine) and have the ponds constructed as recommended. To save labour and time, each pond should be accessible by a vehicle especially if one plans to harvest 100 kg or more of fish at a time (See Plate 7.3).

7.3.2. Considerations when Harvesting Fish for Market

When fish are to be harvested for market, ensure that the market has been arranged first and is ready to take the fish. It is advisable, not to feed fish two days prior to harvesting for sale. If possible get a sample of fish out yourself to check the flesh quality and/or taste. Catfish fed on offals tend to be extremely fatty. They should be kept completely off feed for at least two weeks to burn off extra fat depending on how fatty the fish are.

7.3.3. Holding Fish for Market

If you are to meet a large order, harvest the fish required the day before and keep the fish for the market in a cage within the pond (see Plate 7.4). In this way, when the customer comes, all that needs to be done is load the fish. Being able to hold fish in this manner enables one to make deliveries on time, especially the early morning ones. Small sales can also be made from the holding cage. Hence, the number of times the pond is seined for a farmer who sells small amounts at a time is minimised. Consequently, the less stress inflicted upon the fish that remain in the pond and survival rates improve. However, what makes life easy for the farmer also makes it easy for thieves.

When in a holding cage for market, fish should not be fed. Fish can remain in a cage for a few days if the cage is well covered so they do not jump out. A customer who made an appointment for supply should not have to come to the pond and wait for you to seize the pond.
7.3.4. Post-Harvest Handling and Value Addition

A farmer's aim is to get the best price possible for the fish he/she has raised. Hence, the farmer must be in position to produce and maintain good quality to the customer. The advantage with fish farming, is that one has the ability to control and improve quality right from the start of the production process. Some of the factors that affect fish quality in fish farming are:

1. Quality of the feed and feeding regime which affect flesh composition, flavor and texture. Avoid using feeds with higher energy and fat than is recommended because the flesh becomes fatty.
2. Stress to the fish that result in extreme reduced feed intake. This results in increase in the water content of the flesh and poor texture. Therefore minimize fish stress during production.
3. Stop feeding if one is using pellets for at least 1 day before harvest. This allows the gut time to empty which aids gutting and cleaning of the fish. When one has used offals to feed catfish, the fish should be kept off feed longer to ensure their guts are empty because it takes longer for the offals to digest and to burn off extra fat.
4. Catfish fed only on offals should therefore be kept of feed for a minimum of 2 weeks, or longer if they are still too fatty.
5. Kill the fish rapidly before gutting or filleting. Do not allow them to jump all over the place before slaughter as the violent body movements can cause bruising on the fish flesh.

After harvest:
Avoid contamination. Use clean water and containers and avoid placing fish directly on the ground.

If fish are to be sold fresh, the best way to guarantee freshness is to sell the fish alive or deliver it live to the customer, if possible (see Plate 7.5a). When table-sized catfish are being transported live to the market, use a container with a wide opening rather than one like a water tank with a narrow spout and do not fill the tank with water to the brim. Troughs or buckets can be used. This is because adult catfish can come up to the water surface to breathe air in the event that the dissolved oxygen level in the tank drops. If the spout is narrow, the surface area of water exposed to air is small and only a few fish will be able to come up to breath at a time. The result will be several of the fish in the tank dying. Cover the tank with netting to make sure the fish do not jump out.
Alternatively, large catfish can be kept alive in wet jute bags as long as they are not wrapped too tightly. They must be able to work their gill covers (opercula).

If fish cannot be kept alive, keep them iced in form of fillets or whole gutted. Whole fish can also be filleted. The fillets can be sold fresh or smoked (See Appendix 7 for how to fillet fish).

Smoking catfish not only improves the shelf life but also adds value to the fish. However, to get the best quality, only smoke the freshest fish, not fish that is going bad (see Appendix 8 on how to smoke fish).

7.4. Records

Record the details of all samplings and harvests in the pond management record sheet. When the pond has been drained at the end of each production cycle, calculate the survival rate and overall FCR (see figure 9.2 in section 9.1.1. (pages 155-156) for an example of properly filled in record sheet).

Then draw a line across the sheet to begin a new production cycle or begin a new sheet for that pond. Remember that calculations based on sampling are only educated guesses. It is only at pond draining that the real survival rate, FCR and yield can be calculated.
Summary Guidelines for Handling, Sampling and Harvesting Fish

1. Plan beforehand and collect all the materials and personnel you require.

2. Do not feed fish for a day or two prior to major handling (sampling and harvesting). In cases where fish have been fed offals, do not feed for a minimum of four days prior to harvest.

3. Use the right equipment and ensure fish are always in water except for when it is really necessary to remove them (e.g., at weighing).

4. Confine the fish for as short a time as possible.

5. Work fast and be efficient.

6. Do not sample more fish than necessary and avoid seining the entire pond. (a sample of 15 to 30 fish is usually sufficient)

7. Record the sampling and harvest data as well as any details of the activity in the pond management record sheets.

8. Assess the data and improve the next time.

Guidelines for Post-Harvest Handling

1. Do not place the fish directly on the ground. Keep the harvested fish in a clean container – the basket, basin, tank.

2. If the fish is to be processed, slaughter and bleed the fish quickly rather than let it die own its own slowly to ensure a good texture.

3. Use only clean utensils and tables. Use materials that are easy to clean.
Chapter 7 – Handling, Sampling and Harvesting

Plate 7.1: Tools Used to Sample

a. Seine Net (a Bag is not necessary for small ponds or small sample sizes)

b. Fish Basket

c. Weigh balance

d. Field note Book and Pencil (usually, the data are recorded in the field book and later transcribed to the respective pond record sheets.)
Chapter 7 – Handling, Sampling and Harvesting

a. Seining a Grow-out Pond with a Commercial Pond Seine.
   When sampling, only a quarter of the pond needs to be seined off.

Plate 7.2: Sampling a grow out

b. Holding the sample.
   Fish are held in the bag until they are ready to be handled. Only what can be weighed at each moment is removed using the fish basket.
c. **Weighing the Fish.**
The only time fish should be out of water is when the fish basket is lifted to the weighing scale.

**Plate 7.2: Sampling, continued**

d. **Returning Fish into the Pond.**
Release the fish gently into the water. Do not throw them back into the pond. They should be counted back into the pond so the average weight can be calculated.
Plate 7.3: Accessibility to Ponds
Being able to access all ponds with a vehicle is important especially when large amounts of fish are to be harvested at a go.

Plate 7.4: Temporary Holding of Fish in Ponds for Market
Catfish can temporarily be held in the pond for market in a cage or hapa. The cage or hapa must have a secure cover to prevent the catfish jumping out or other predators entering the cage. In this case, the cage or hapa can be placed on the pond bottom.
a. Live Fish Sales.
The best way to guarantee freshness is to deliver and sell it alive to the customer. It also draws a crowd, which give free publicity.

Plate 7.5: Marketing and Adding Value to Farmed Catfish Products

b. Smoking Catfish with a Chokor Smoker

c. Catfish Fillet and Tools Used to Fillet Catfish
CHAPTER 8

FISH HEALTH AND PREDATOR CONTROL

Maintenance of good fish health is critical to profitable fish culture. Slow growth, poor feed conversion, low yields, increased disease incidence and mortality, consequently, low profitability are the results of poor fish health. Physiological stress is the fundamental cause of most fish health problems. The best way to manage fish health is through prevention. Practical health management is based on stress management. This involves preventing and minimizing stress to the fish in the culture environment through:

1. **Good water quality management.** This begins by picking a farm site with good water quality and quantity. Maintain water quality at non-stressing levels,
2. **Good nutrition.** Feed high quality feed (nutritional and physical aspects) in the proper size and amounts.
3. **Good stocks of fish.** Only stock healthy, unstressed and disease-free fish and handle them as recommended.

Remember,

1. Fish are cold-blooded animals and respond directly to environmental conditions.
2. Aquaculture systems are innately unstable. This is because, their environmental components (chemical, physical and biological) are constantly changing, as fish biomass and nutrient inputs (feed) increase over time. The challenge to the farmer, is to maintain environmental parameters within the fishes normal to tolerance limits during the course of production.
3. Catfish do not have scales to protect them so rely on mucous to protect their skin. When the mucous is rubbed off, the catfish are very prone to infection and parasites.
4. Fish do not have eyelids and cannot protect their eyes when they are being rubbed against each other or being poured from a basket or net.

8.1. Fish Stress

Stress is an abnormal physiological condition of fish that results when the fish's collective adaptive responses to environmental factors are extended to, or approach its limit of tolerance. When fish are stressed,
or continuously exposed to stress, their immune system becomes weakened (just as people do when they are poorly nourished, overworked or exposed to harsh environmental conditions). Consequently, their ability to fight disease is reduced and they then succumb to infections and fall sick. In severe or prolonged cases, this may lead to death. Stress can be acute or chronic. Chronic cases are less obvious to the eye but result in reduced feeding response, higher FCRs and lower returns.

Other practical on-farm indicators of stressed fish are changes in behavior (such as when a fish prefers to remain alone rather than stay with the rest of the group), changes in their physical appearance (for example, they may become darker, lose fins), reduced feeding response and poorer growth rates.

**Table 8.1**: Generalized illustration of how Warm-Freshwater Fish might respond to Specific Environmental Factors under Certain Conditions

Adapted from Schmittou et al., 1998. Note clarias have slightly different temperatures for each of these categories.

<table>
<thead>
<tr>
<th>Fish Response</th>
<th>Environmental Factor</th>
<th>pH</th>
<th>NH₃-N</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaustion and Death</td>
<td>Death</td>
<td>11.0</td>
<td>0.5</td>
<td>&gt;34</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Short-term tolerance limit</td>
<td>9.8</td>
<td>0.4</td>
<td>33</td>
</tr>
<tr>
<td>Adapt</td>
<td>Long-term tolerance limit</td>
<td>9.5</td>
<td>0.2</td>
<td>31</td>
</tr>
<tr>
<td>Escape</td>
<td>Upper optimum limit</td>
<td>9.0</td>
<td>0.0</td>
<td>30</td>
</tr>
<tr>
<td>Normal</td>
<td>Ideal</td>
<td>6.5 to 8.0</td>
<td>0.0</td>
<td>26 to 28</td>
</tr>
<tr>
<td>Escape</td>
<td>Lower optimum limit</td>
<td>6.0</td>
<td>0.0</td>
<td>15 to 24</td>
</tr>
<tr>
<td>Adapt</td>
<td>Long-term tolerance limit</td>
<td>5.5</td>
<td>0.0</td>
<td>5-15</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Short-term tolerance limit</td>
<td>5.0</td>
<td>0.0</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Exhaustion and Death</td>
<td>Death</td>
<td>4.0</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>
### Chapter 8 – Fish Health and Predator Control

#### 8.1.1. Common Sources of Stress

Most stress in fish farming arises from physical, chemical, biological and procedural sources (see table 8.2: below).

**Table 8.2: Common Stressors in Production**

<table>
<thead>
<tr>
<th>Chemical Stressors</th>
<th>Biological Stressors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Acidity</strong></td>
<td></td>
</tr>
<tr>
<td>pH 6.5 to 8.0 ideal</td>
<td></td>
</tr>
<tr>
<td>pH ≤ 5.5 and ≥ 9.5 stressful</td>
<td></td>
</tr>
<tr>
<td>pH ≤ 4.0 and ≥ 11.0 are lethal</td>
<td></td>
</tr>
<tr>
<td><strong>2. Alkalinity</strong></td>
<td></td>
</tr>
<tr>
<td>Unlikely to cause stress</td>
<td></td>
</tr>
<tr>
<td>Require more than 20 mg/l to buffer against stressing pH fluctuations</td>
<td></td>
</tr>
<tr>
<td><strong>3. Hardness</strong></td>
<td></td>
</tr>
<tr>
<td>Stressful when concentrations are below 10 to 20 mg/l</td>
<td></td>
</tr>
<tr>
<td><strong>4. Heavy Metals</strong></td>
<td></td>
</tr>
<tr>
<td>In alkaline water, Cu and Zn are stressful at 0.05 mg/l and toxic at 0.1 mg/l</td>
<td></td>
</tr>
<tr>
<td><strong>5. Metabolic Wastes</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ammonia</strong>:</td>
<td></td>
</tr>
<tr>
<td>0.02 mg/l - chronic stress</td>
<td></td>
</tr>
<tr>
<td>0.05 mg/l - acute stress</td>
<td></td>
</tr>
<tr>
<td>Growth may be reduced by 50% at 0.4 mg/l</td>
<td></td>
</tr>
<tr>
<td>Mortality may begin at 0.5 mg/l</td>
<td></td>
</tr>
<tr>
<td><strong>Nitrite</strong>:</td>
<td></td>
</tr>
<tr>
<td>0.01 mg/l stress</td>
<td></td>
</tr>
<tr>
<td>0.02-1.0 mg/l can get 'brown blood disease' and mortality</td>
<td></td>
</tr>
<tr>
<td><strong>Physical Stressors</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1. Temperature</strong></td>
<td></td>
</tr>
<tr>
<td>Stressful if fluctuates by 3° to 5°C in less than an hour</td>
<td></td>
</tr>
<tr>
<td><strong>2. Light</strong></td>
<td></td>
</tr>
<tr>
<td><strong>3. Sound</strong></td>
<td></td>
</tr>
<tr>
<td>Sudden sharp loud noises can cause fish to panic</td>
<td></td>
</tr>
<tr>
<td><strong>4. Low Dissolved Oxygen</strong></td>
<td></td>
</tr>
<tr>
<td>No matter what the reason, as long as fish cannot access the oxygen they require, they will be stressed</td>
<td></td>
</tr>
<tr>
<td><strong>Procedural Stressors</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1. Associated with handling, holding, transporting and treating fish</strong></td>
<td></td>
</tr>
<tr>
<td><strong>2. Crushing effect of gravity when holding fish out of water in nets/baskets</strong></td>
<td></td>
</tr>
</tbody>
</table>

Often clinical signs of outbreaks of *disease* do not occur among unstressed populations. The most common stressors to fish in ponds that
lead to disease are, (in order of observed occurrence and disease severity):

1. fish handling (pre-stock seining, holding, transporting and stocking, post-stock sampling, predators).
2. low dissolved oxygen levels
3. poor nutrition, especially vitamin C deficiency (See Plate 8.1).

8.1.2. Stages of Stress
In order to control stress, one must be able to understand what the stressors are and recognize fish under stress. There are four distinct stages of stress that are physically identifiable in fish:

1. Alarm Reaction. This is when the fish try to escape the stressor. An example of this is when stocking the pond and instead of swimming out freely into the pond, they skip across the water surface.

2. Resistance. When the fish react to the stressor through physiological adaptation. For example, when dissolved oxygen levels are low, the catfish will come out of the water to gasp atmospheric air.

3. Fatigue. The fish are noticeably weak but respond to stimuli.

4. Exhaustion. This is when the fish’s physiology is unable to sufficiently adapt to a persisting stressful condition, and it can no longer respond to stimuli.

The impact of stress on fish depends on the duration and magnitude of the stress condition. Death is the ultimate result. Sub-lethal stress conditions cause reduced fish growth, low yield, poor feed conversion and poor health, including pathological diseases.
Table 8.3: Typical Appearances of Fish at Different Stages of Stress

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>Healthy, alert, normal activity, normal body colour, social (schooling) activity</td>
</tr>
<tr>
<td>ESCAPE</td>
<td>Healthy, alert, increased activity and body movement, slight increase in opercular (respiration) movement, possible slight body color change (usually darker), schooling fish remain together.</td>
</tr>
<tr>
<td>ADAPT</td>
<td>Healthy, alert, usually swimming higher than normal in water, increased opercular movement (look like breathing fast), schooling fish remain together</td>
</tr>
<tr>
<td>FATIGUE</td>
<td>Lethargic but sufficiently alert to avoid dip-net capture, reduced activity and movement, usually gasping at or near surface, color change distinct (usually much darker), schooling fish separate to individuals</td>
</tr>
<tr>
<td>EXHAUSTION</td>
<td>Hanging listlessly, usually disoriented (commonly upside down) at surface, little or no response to avoid dip-net capture</td>
</tr>
</tbody>
</table>

8.2. Predators and their Control

Predators are a major source of stress to fish and can also cause significant losses. **NOTE:** Large African catfish can predate on smaller ones; so, maintaining uniform sizes within ponds is critical.

Predators:

1. consume the fish in the pond,
2. consume the fish’s feed,
3. may transmit parasites and other infections to fish,
4. scare the fish when they are chasing them up, and
5. cause physical injury to several fish in the process of hunting.
6. May trans-locate fish to a different pond

The wounded fish left in the pond consequently cannot get to the feed as well as the other normal fish. This is because, for example, their eyes
might be injured or their open wounds might get infected, etc. Consequently, their growth rate slows and chance of survival drops. Controlling predators is therefore important in commercial production.

The most common predators are:

1. **Humans Beings**
   Provide security to your premises by fencing off and keeping the place active. Some places have gotten local authorities to recognize how harmful theft is to the development of commercial fish farming in their area and have enlisted their help in prosecuting fish farm thieves. As well, be a good neighbor and make sure others appreciate the fact your farm is there. This can create “social pressure” to reduce thievery.

2. **Frogs and Snakes.**
   The populations of frogs and snakes can be controlled by keeping premises around clean and clear. Do not allow bushes to grow around the ponds. Water channels should also be kept clean and clear. Screen the ponds as recommended. Screens within the water channels also help reduce frogs’ access to the ponds. Frogs tend to come into pond areas via the water channels. Short grass around the ponds reduces hiding places for the snakes and frogs, which makes them more vulnerable to predation by hawks.

3. **Birds.**
   a. Wading birds (such as the heron, marabou stork, hammerkop) walk into the pond to catch fish. To control wading birds, ensure pond average water depths of 1 meter so that the birds are unable to stand in the pond (See Plate 8.3b).
   b. Diving birds (such as the king fishers, ducks) fly over or swim on the water surface then dive down to pick the fish. Tying string at close intervals over the pond prevents them from being able to fly away once they have come down or dive through the strings (see Plate 8.6b).
   c. Avoid setting your ponds near places where birds can perch, such as having pond under telephone or electricity wires/poles, trees, etc. These provide a spot for birds of prey to sit, watch the fish and time when best to hunt them (see Plate 8.6a). Tall sticks placed in ponds are excellent perches for kingfishers. If sticks are required in a pond, they should be kept as short as possible.
d. Scarecrows or sudden loud noises may be used to scare away birds. However, if this option is used, change the tactics at least every two weeks. This is because the birds learn fairly fast that the object is not life threatening and will eventually ignore the scarecrow or noise (see Plate 8.6g).

e. Learn at what time birds come to hunt fish. Most times, birds come down to get fish soon after feeding, early in the mornings or late in the evening. Be around at such times to scare away the birds. Human activity helps to keep birds away.

f. Do not leave any dead animals or feed, etc. lying around ponds because birds may come to feed upon them. Dispose of all rubbish and carcasses by burying them away from the pond area.

g. String may be tied across the pond or specifically around the feeding area to prevent diving and wading birds predating upon the fish.

h. One may also train dogs on the farm to scare away birds (See Plate 8.6e).

Cormorants and pelicans are usually the most nuisance of predators because they fish in groups can crowd the fish just as if they were a seining crew.

Birds do provide some service by removing unhealthy fish from the ponds. However, some birds develop the habit of “following the feeder” and end up removing healthy fish. So, it is best stay at the pond until fish have consumed the feed.

Birds can be a “bio-indicator”. They will begin to gather around a pond where the fish are having trouble. So, if you see a gathering of birds on your farms, check it out.

4. **Monitor Lizards and Otters.**

Clear the bush around so that they have no nesting close by. Set traps to catch monitor lizards and otters. Dogs are also very good at chasing away these predators. Otters are most likely to show up at night.
Summary Guidelines for Preventing Stress and Disease to Fish

The following is a check list of management guidelines to avoid fish health problems.

1. **Select Good Fish Stock.** Fish in poor health and physical condition will grow slowly, convert feed poorly and general production performance will always be lower than for fish of select quality. Guidelines for choosing stock have been discussed in Chapter 3.

2. **Handle Fish With Care** when collecting, holding, transporting, stocking and sampling. Improper handling of fish is one of the most serious and common stressors that result in poor fish production, disease and death.

   The guidelines for proper handling include:
   a. identify and minimize all chemical, physical and biological stressors for each handling situation.
   
   b. be especially careful to avoid the most common stressors:
      - never remove fish from water unless absolutely necessary,
      - do not hold fish out of water longer than absolutely necessary, and do not handle with dry hands,
      - do not overload fish in nets and containers out of water,
      - do not hold fish at high densities in closed water containers and tanks without proper aeration and water quality control,
      - do not change water temperature around fish by more than 3 °C at one time and by 2 °C/hour over long periods of time,
      - do not measure and weigh individual fish unless there is some specific need for that information and the fish are expendable,
      - avoid using chemicals, including anesthetics, when handling fish.

3. **Feed Fish with only Good Quality Feeds.** Proper nutrition is not only essential for good growth and feed efficiency but for good health as well. Good quality feeds prevent nutritional diseases and are critical to the prevention of other pathogenic and stress-related diseases.

   Guidelines for feed quality:
   - Use nutritionally-complete pellets, 30-32% protein fortified with stabilized vitamin C and mineral supplements for fish.
   - Use freshly manufactured feeds. Avoid feeds older than 2 months.
Always check date of manufacture. Note that some feeds will remain good longer than others if they are sufficiently dried and are made with stabilized vitamins, or extra vitamins, mold inhibitors and anti-oxidants.

- Do not use molded, spoiled or otherwise degraded feed.

4. **Never Apply Drugs or Chemicals to the Fish or their Water Unless it is Absolutely Necessary.** A salt dip of 0.5% is recommended for prophylaxis when handling fish. (This is 5 grams of salt in every liter of water)

5. **Maintain Good Water Quality Control in Ponds.**
   - Construct ponds as recommended
   - Ponds must be at least 1 meter average water depth
   - Practice *static water* management and avoid leaking ponds
   - *Stock* and manage based upon *carrying capacity* for feed specifications.

6. **Control Predators**
   - Minimize the amount of vegetative growth around ponds as these act as a refuge for many potential predators e.g. Birds, snakes, otters, monitor lizards, thieves.
   - Keep the place around farm active and be observant.
   - Keep area around ponds clean.
   - In the event that some predators become uncontrollable with non-lethal means, contact the Uganda Wildlife Authority.

Use non-lethal means to control predators. The common 'predators' other than man are wildlife and are protected by law (see appendix 10). In the event that birds, otters, monitor lizards, snakes become uncontrollable, report to the Uganda Wildlife Authority who will then have these animals captured and trans-located.

If you attempt to use poisons, a non-target animal may be killed, including people, and you can be held responsible.
Plate 8.1: Crack Head
A cracked head is a sign of vitamin C deficiency in Catfish.

Plate 8.2: Aeromonas sp.
Bacterial infections become common when fish are kept for prolonged periods in water of poor quality and are fed a non-balanced diet. This case was obtained from a pond that had reached its carrying capacity and oxygen levels were below 0.2 ppm and total ammonia levels above 20 ppm over a period of a month. For grow-out fish, the most economical treatment is to withhold feed, flush pond and reduce stocking densities. After improving environmental conditions re-start feeding.
Plate 8.3: Common Predatory Wading Birds (Pictures courtesy of UWA)
Chapter 8 – Fish Health and Predator Control

Plate 8.3: Common Predatory Wading Birds, cont. (Pictures courtesy of UWA)

- g. Egret
- h. Shoe-billed stork

Plate 8.4: Predatory Diving Birds

- a. Pied kingfisher with fish
- b. Kingfisher getting ready to dive
a. **Fish Eagle**: usually picks from the water's surface with its talons.

*Cormorants (diving birds), Marabou Stork and Yellow Bill, wading birds (Picture courtesy of UWA)*

**Plate 8.4: Predatory Diving Birds, continued**
a. Monitor Lizard  
b. Otters  
c. Crocodiles  
d. Human Beings  

Plate 8.5: Other Predators
Chapter 8 – Fish Health and Predator Control

a. **Birds Perched on Electricity Wires.** As much as possible, locate ponds where there is little room for birds to perch or other animals to hide around the pond. Picture courtesy of Uganda Wildlife Authority.

b. **Strings Tied Close Over the Pond.** Strings tied close over the pond, especially over the feeding area prevent diving birds entering. When tied around ponds, entry of wading birds is also interfered with.

c. **Kingfisher with Fish.** Keep area around ponds clean. Do not leave rubbish such as dead fish or feed lying around. Picture courtesy of Uganda Wildlife Authority.

d. **Marabou Stork by Pond Side.** Wading birds cannot walk into ponds whose water is deep to fish. The recommended average pond water depth is 1m.

**Plate 8.6: Controlling Predators**
e. Dogs
Dogs may be trained to scare birds and otters away. They can be very effective.

f. Pond with Little Freeboard
Birds cannot build nests in the pond banks after this pond is full as there is too little room.

g. Scare-devices
Remember to Change the Scare-device and tactics at most every two weeks because birds can learn that the device is not a threat.

Plate 8.6: Controlling Predators, continued
CHAPTER 9

PRODUCTION RECORDS, THEIR USE AND INTERPRETATION

As opposed to terrestrial animals, fish are always under water during the production cycle. The only time a farmer sees them is at feeding, if they feed by response, or at sampling. The moments when one can visibly observe the fish’s behavior, condition or growth are therefore, limited. The only other source information on the fish’s status and performance are the trends in the daily records kept.

Records for commercial fish production are therefore, not just a means by which one assesses total inputs and outputs. They are the only source of information by which one can adjust daily management requirements. Farm records are the only most reliable way, of evaluating performance and making future plans. Farm records can demonstrate if changes in management are improving or harming the fish’s performance and what the farms’ economic returns actually are. They also help the farmer determine when theft occurs. Record keeping must be a continuous process in fish farming because in real-life, circumstances on the farm change continuously, on a daily basis.

Good Farm Records serve a definite purpose. They should be easy to complete, easy to update, enable quick decision making and facilitate quick action. Filling in farm records should not be time consuming. Information should not have to be re-written several times, in several forms or transferred more than once. Re-writing and re-transferring the same information more than once is not only time consuming, but the chances of making errors during re-entry increase. Remember, record keeping incurs costs both directly and indirectly. There is no point keeping records from which no useful information can be derived from them.

The recommended production records for fish farms are the pond management and feed record sheets. The former is filled in only when a management activity is undertaken and the latter is filled in on a daily basis. The feed sheet is filled on a daily basis because fish are fed every day (even when not fed, that should be recorded). Farmer’s should also have records of accounts for all expenditures and sales. These records
together, enable one analyse and manage their operations for productivity and returns. This is essential when running any commercial enterprise.

**9.1. The Pond Management Record Sheet**

**9.1.1. The Function and Use of Pond Management Records**

The purpose of having a fish pond, is to grow fish profitably. To grow fish profitably, a farmer must provide optimal conditions within the specific pond. Pond management requirements are pond specific and not batch specific. This is because unit management requirements are adjusted based on what is in the pond at any given time and the specific pond peculiarities, such as bottom soil quality, etc. Each pond is a separate ecosystem that needs to be accordingly managed. Even when ponds are side by side and given equal treatment, they can react very differently thus requiring different management adjustments.

**9.1.1.1. The Pond Profile**

**Pond Name:** Each pond on the farm should be distinctly identified so that one can follow-up closely the management requirements of that pond and its products. All ponds should therefore, have an individual name/number. Likewise, each pond should have its own management record sheet. Naming ponds independently also makes it possible to track the efficiency of production on the farm down to specific units.

**Pond Size:** The functional size of a pond, is equivalent to its actual water surface area. This is because fish grow only in water, and not the space above or around the water surface. In addition, it is the surface area of the water exposed to sunlight that determines the productivity of that water volume in static water ponds.

**9.1.1.2. Pond Management Activities**

The management activities that are undertaken in pond production can be broadly categorized as:

a. **Stocking**, which marks the start of a production cycle (see Chapter 4 above for more details). In the column for details, record the total number stocked, total weight stocked, source of the stock as well as any other details about the stock.

b. **Treatment.** This includes both treatment to the pond and fish. Treating the pond means adding inputs such as fresh water, fertilizer, lime, disinfectants, aeration, etc. that serve to improve
the water quality conditions in the pond for fish production. Treatments may be undertaken before *stocking* or during the course of production. Fish may also be removed from the pond temporarily for treatment. Record the details of what was actually done, the reason why, what specific treatments were used and the quantities used. (see Chapter 5 for more details).

c. **Sampling** This is the temporal removal of fish from the pond to assess their growth and health status. Record the details of total weight of the sample, the total number sampled as well as average weight. Never record only the average weight, because if a mistake is made in the calculation, there will be no way of correcting that mistake. If actual weights are not taken, then note that the weight was estimated as well as the means used to gauge size. For example, one might have estimated size with the help of a ruler; in this case, record the length of the fish. On the other hand, if you used the palm of your hand, then record that the fish was twice as long as the palm of your hand. After the observations fish are returned to the pond (see Chapter 7.2 for more details).

d. **Harvesting** Harvesting is the removal fish from the pond without returning it to the pond. Record the total number harvested, total weight harvested, average size of the fish harvested as well as the reason for harvest. For example, fish may have died due to stress, may have been sold and/or transferred to another pond. (See Chapter 7.3 for more details).

e. **Draining** This is the removal of all the water from the pond. It marks the end of the pond’s production cycle (see Chapter 7.3 for more details). At drainage, record the details of the total number harvested, total weight harvested and average size of the fish harvested. Also total up the feed consumed during the cycle. Calculate the cycle’s FCR, survival rates as well as net production.

Pond management activities are not undertaken on a daily basis. The management activities are categorized as above. One needs only tick and record the date on which a specific activity was done, and then note the details regarding the general activity area. See figures 9.1 that illustrates the use a pond record sheet. Figure 9.2 gives an example of a properly filled pond record sheet respectively. Keeping the pond record in such a manner, avoids duplication of records and saves paper as well as
time. It also makes it possible to review all the management activities undertaken in a pond, as well as monitor the pond’s inventory from a single sheet of paper during the course of production.

9.1.1.3. The Pond’s Inventory

On the pond management record sheet are two columns (the total number and total biomass columns) on the right hand side (see figure 9.1). These columns serve the purpose of monitoring the pond’s inventory, in terms of both fish numbers and biomass. The total number and total biomass columns are important, not just because they serve the function of being the pond’s balance sheet, but because they also enable one keep track of the pond’s performance trends at a glance. They enable the farmer to estimate with relative accuracy, how much fish shall be available for the market in advance.

At the end of each production cycle, calculate the:

1. **Net Production**

   \[ \text{Net Production} = \text{total biomass harvested} - \text{total biomass stocked} \]  

   \[ \text{Equation 8} \]

2. **Survival (%),**

   \[ \text{Survival} (\%) = \frac{\text{total number harvested}}{\text{total number stocked}} \times 100 \]  

   \[ \text{Equation} \]

   The total number harvested includes all fish registered as harvested, be they for sale, home consumption or dead. This is because whether or not fish may have died earlier, the still did cost money and consumed feed.

3. **Economic FCR.**

   The FCR at the end of the cycle is,
   \[ \frac{\text{total amount of feed consumed by the fish that cycle}}{(\text{total biomass harvested} - \text{total biomass stocked})} \]  

   \[ \text{Equation} \]

   The total biomass harvested should include the weight of the fish harvested intermittently including those harvested at draining.

   These values are important because they are the immediate indicators of production performance as well as whether or not profits were made that cycle.
**Chapter 9 – Production Records, Their Use and Interpretation**

**HOW TO USE THE POND/TANK MANAGEMENT SHEET**

In this space write the name or number of the pond/tank. Each pond or tank on the farm should have its own record sheet. Never share a record sheet between ponds.

In this space write the area of the Pond whose number you have recorded in the units you are familiar with for example m², hectares, square feet or acres. If using a Tank record the tank size in terms of volume eg. m³, ft³.

In this space state what the pond or tank is being used to produce e.g. Grow-out, nursery, broodstock, holding market fish.

In this column, record the total estimated number of fish in the pond or tank and will decrease when fish are harvested or die.

In this column, record the total estimated weight of fish in the pond is recorded. As fish grow, weight will increase. Do not forget to record the units you use to measure weight.

In this column write the details of exactly what you have done depending on which of the columns you have picked (e.g. If you stocked that day, in this column you would write the species of fish stocked, number stocked, their average size (weight and/or length) and source. If you estimate the size, record it as an estimate, eg estimated weight = 10g.

These last two columns act as the ponds balance sheet and serve to show how many fish and the total weight of fish in the pond during the course of production. They are useful for monitoring your farm/pond inventories and feed requirements.

Write down the date in this column whenever you undertake any activity other than feeding feed to the fish in the pond/tank.

In this column, record the total estimated number of fish in the pond. Therefore it will increase when fish are added to the pond or tank and will decrease when fish are harvested or die.

Tick (√) whenever you add fish or stock your pond or tank, tick this column after having filled the date.

Tick (√) in this column whenever you do anything that affect/to improve the water quality conditions or levels in the pond (e.g. Liming, adding water, fertilization, etc.

Tick (√) this column whenever you remove fish and then return them back into the pond (i.e. sample the pond) to check their growth, health, etc.

Tick (√) whenever fish are removed but not returned into the pond (harvested) e.g. When you remove fish for sale, to eat, to transfer to another pond or if dead fish are removed from the pond.

Tick (√) this column when you drain the pond completely of all water. Draining a pond marks the end of it production cycle.

**Figure 9.1:** How to use the pond/Tank management sheet
## Example of a Properly Filled Pond Record Sheet

**POND/TANK MANAGEMENT RECORD SHEET**

<table>
<thead>
<tr>
<th>Date</th>
<th>Stock</th>
<th>Treat</th>
<th>Sample</th>
<th>Description (species, numbers, weights, sizes, where from, where to)</th>
<th>Total No.</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.04.06</td>
<td>√</td>
<td></td>
<td></td>
<td>50 kg lime</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.04.06</td>
<td>√</td>
<td></td>
<td></td>
<td>filled pond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.04.06</td>
<td>√</td>
<td></td>
<td></td>
<td>3,000 catfish @ 10g from Umoja Fish Farm - Lot No. B20</td>
<td>3,000</td>
<td>30 kg&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>18.04.06</td>
<td>√</td>
<td></td>
<td></td>
<td>10 fish died</td>
<td>2,990</td>
<td>29.9 kg</td>
</tr>
<tr>
<td>20.05.06</td>
<td>√</td>
<td></td>
<td></td>
<td>100 fish, total weight = 5.6 kg. Av. Weight = 56g. Amount feed consumed at interval = 90 kg. Interval $FCR = 90kg/(167.4-30)kg=0.6$</td>
<td>2,990</td>
<td>167.4 kg&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>15.06.06</td>
<td>√</td>
<td></td>
<td></td>
<td>88 fish, total weight = 15.8 kg. Av. Weight = 179.5g. Amount feed, interval = 370 kg. $FCR=370kg/(536.7-167.4)kg=1.0$</td>
<td>2,990</td>
<td>536.7 kg</td>
</tr>
<tr>
<td>23.07.06</td>
<td>√</td>
<td></td>
<td></td>
<td>67 fish, total weight = 27.6 kg. Av. Weight = 412g. Amount feed, interval 834.4 kg. $FCR interval = 834.4kg/(1,232-536.7)kg=1.2.$</td>
<td>2,990</td>
<td>1,232 kg</td>
</tr>
<tr>
<td>26.07.06</td>
<td>√</td>
<td></td>
<td></td>
<td>2 fish died</td>
<td>2,988</td>
<td>1,231.1 kg</td>
</tr>
<tr>
<td>30.08.06</td>
<td>√</td>
<td></td>
<td></td>
<td>72 fish, total weight = 43 kg. Av. Weight = 597g. Total feed interval = 938.1 kg. $FCR interval = 938.1kg/(1783.8-1,232)kg=1.7$ $FCR$ higher than feed chart for fish this size. Last column shows pond almost at carrying capacity. Farmer decides need to reduce amount of fish in pond and starts looking for market.</td>
<td>2,988</td>
<td>1,783.8 kg</td>
</tr>
<tr>
<td>12.09.06</td>
<td>√</td>
<td></td>
<td></td>
<td>Sold 50 fish. Estimated average weight 600g</td>
<td>2,938</td>
<td>1,753.8 kg</td>
</tr>
<tr>
<td>28.09.06</td>
<td>√</td>
<td></td>
<td></td>
<td>flushing water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.10.06</td>
<td>√</td>
<td></td>
<td></td>
<td>41 fish, total weight 28.6 kg. Av. Weight = 697.6g. Total feed interval 595.6 kg. $FCR interval = 595.6kg/([2,051+30]-1,783.8)kg=2.0$. $FCR$ higher than feed chart for fish this size. Last column also shows pond almost at carrying capacity. Farmer decides need to reduce amount of fish in pond. Seriously looking for market for at least 25% of fish in pond.</td>
<td>2,938</td>
<td>2,051 kg</td>
</tr>
<tr>
<td>23.10.06</td>
<td>√</td>
<td></td>
<td></td>
<td>sold 600 fish, total weight 480 kg. @ 800g</td>
<td>2,338</td>
<td>1,571 kg</td>
</tr>
<tr>
<td>15.11.06</td>
<td>√</td>
<td></td>
<td></td>
<td>500 fish (450-sold, 50 home), @ estimated average weight 500g.</td>
<td>1,838</td>
<td>1,321&lt;sup&gt;c&lt;/sup&gt;kg</td>
</tr>
<tr>
<td>16.12.06</td>
<td>√</td>
<td></td>
<td></td>
<td>50 fish, total weight 47.8 kg. Av. Weight = 956g. Total feed interval 2,099 kg. $FCR interval = 2,099kg/([1,757.1+250+480]-1,321)kg=1.8$. $FCR$ and growth(change in biomass) between 16 dec and 15 nov good and within range as guided by feed chart.</td>
<td>1,838</td>
<td>1,757.1 kg</td>
</tr>
<tr>
<td>24.12.06</td>
<td>√</td>
<td></td>
<td></td>
<td>Sold 1,000 fish of total weight 1012 kg.</td>
<td>838</td>
<td>745.1 kg</td>
</tr>
</tbody>
</table>
Chapter 9 – Production Records, Their Use and Interpretation

Figure 9.2: An Example of a Properly Filled Pond Record Sheet.
(Remarks in italics are merely for explanation and would not be written in the record.)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.01.07</td>
<td>Removed 712 fish (all sold), total weight 609 kg</td>
<td>0 0 kg</td>
</tr>
<tr>
<td></td>
<td>Total number of fish harvested 2,874</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Survival = 96%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total feed consumed (from stocking to drainage) = 4,678 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$FCR = \frac{4,678}{(2381kg^d - 30kg)} = 1.99$</td>
<td></td>
</tr>
<tr>
<td>27.01.07</td>
<td>Filled pond</td>
<td></td>
</tr>
<tr>
<td>31.01.07</td>
<td>2,500 catfish @ 20 g from Mpiigi Fish Farm - Lot No. 017</td>
<td>2,500 50 kg</td>
</tr>
<tr>
<td>04.03.07</td>
<td>112 fish, total weight 7.6 kg. @ 68 g</td>
<td>2,500 170 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Interval amount of feed is the feed actually consumed by the fish from stocking (or previous sampling day) to current sampling day. This information is obtained from the daily feed record sheet (see figure 9.6 below). Total the feed amount in between sampling days.</td>
</tr>
<tr>
<td>b The change in biomass between intervals is obtained by subtracting the estimated total biomass at the current sampling from the previous sampling. If significant amount fish are removed from the pond after sampling, then estimate interval change in biomass using figure of fish left in pond (see case c above).</td>
</tr>
<tr>
<td>c Fish was harvested and sold in between sampling points. Therefore, the change in biomass is equivalent to the difference in the total weight of the fish sold + the biomass at the most recent sampling - the biomass from the previous sampling date. Because the major objective for monitoring FCR is economic, one should not count fish that have died (i.e. mortality) as part of increase in biomass. This is because no financial gain shall accrue from dead fish, and the feed the dead fish ate is counted as a loss that the farm will have to pay for. Hence, the feed eaten by the dead fish will cause a rise in FCR because their biomass is not counted. This is the reality of your business enterprise. Including mortality in biomass will give a wrong picture of your expected earnings as upon sales, only live harvested whole fish is sold - so your books won't balance.</td>
</tr>
<tr>
<td>d This is the total weight of fish harvested from the pond alive during the production cycle. The total weight of fish harvested is therefore the sum of = (the fish harvested at drainage + that harvested for sale + that harvested for household consumption). Fish that died as a result of stress are not counted for the reasons given in the paragraph c above. Hence, the FCR at the end of the cycle is the economic FCR as it reflects the efficiency of feed use with respect the real cost of all the feed fed added to the pond during the production cycle.</td>
</tr>
</tbody>
</table>

When the pond was at/about carrying capacity, growth rates slow down. The interval FCR at when the pond is at carrying capacity will consequently be higher than what would otherwise be expected. In this case, the farmer decided to reduce the number of fish in the pond in order to bring down the pond’s total biomass to below carrying capacity. In making this decision, though he may have sold the fish at a size smaller than was his targeted size, he saved the situation in good time and was able to obtain a overall FCR at harvest of 1.99. Had the farmer not been monitoring his FCRs and had he not taken immediate action to redress the situation, he would have ended up with an FCR above 2 if he continued to raise the same number of fish in the pond. Therefore, at the end of the cycle, he would have ended up with a loss.
9.1.2. Interpretation of Pond Management Records

The table below discusses possible deductions from trends in the pond records and the relevant management recommendations. The pond and feed record sheets should be assessed simultaneously. As in most cases, trends in one are an indicator of changes in the other.

<table>
<thead>
<tr>
<th>Pond Record</th>
<th>Possible Causes</th>
<th>What Should I do?</th>
</tr>
</thead>
</table>
| **A** Not much positive gain in between samplings in total pond biomass | - Pond is approaching *carrying capacity* or feeding the wrong feed | The options include:  
1. Reduce the fish *biomass* in the pond.  
2. If the pond water smells foul and with frequent low D.Os, it is time to start exchanging at least 50% of the water in the pond daily. This should only be a short-term solution (e.g., 1 week).  
3. Check that you are not putting beyond the maximum amount of feed into the pond that it can assimilate. Improve the quality of feed used to pellets if using powders.  
4. Adjust your pond depth at the next cycle if the water depth in the pond is less than a meter. |
| **B** Sudden Mortalities and Fish Floating on Water Surface with Opercula Open | - Sudden deterioration in water quality most probably due to low dissolved oxygen. Opercula open indicates fish may have been *gasper*. | 1. Stop feeding.  
2. Note whether or not there are any changes in water colour and smell.  
3. *Flush* water through the pond. |
<table>
<thead>
<tr>
<th>Pond Record</th>
<th>Possible Causes</th>
<th>What Should I do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>C] Three to four fish dying every day</td>
<td>- build up of a parasite problem</td>
<td>1. Control the situation to prevent it from worsening by:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ensure good water quality within pond,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- identify and remove possible sources of entry (e.g. check screens are in good condition,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>minimise organic build-up in pond,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>keep area around pond clean so that there is no refuge for animals that may be transmitters of such parasites.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ensure fish are fed adequately, both in terms of quality and quantity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- identify and remove potential stressors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If one has access to diagnostic facilities, then one can send a sample to be checked in order to confirm it is a parasite load and what sort of parasite is affecting the fish.</td>
</tr>
<tr>
<td></td>
<td>- if it is a couple of days after stocking or sampling, due to procedural stress. In this case mortalities should stop within a week at the most.</td>
<td>2. It is often not economical or practical to treat grow-out fish at such a stage.</td>
</tr>
<tr>
<td></td>
<td>- Fish may have been scared or</td>
<td>3. Minimise handling, e.g. do not sample until the situation is under control.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If one has access to diagnostic facilities, then one can send a sample to be checked in order to confirm it is a parasite load and what sort of parasite is affecting the fish.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- if it is a couple of days after stocking or sampling, due to procedural stress. In this case mortalities should stop within a week at the most.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Fish may have been scared or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pond Record</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D) Polluted waters, pond still well below estimated <em>carrying capacity</em>, compounded with high FCR for the size of fish in the pond.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Possible Causes</th>
<th>What Should I do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>frightened. If this was due to a predator, there may additionally be signs of injury on affected fish.</td>
<td>1. Stop feeding. 2. If water quality is really bad (smelling), flush the pond. 3. Re-adjust <em>ration</em> with aide of feeding chart. Cut estimated <em>ration</em> by half, train fish to feed by response, and only add more feed based on their response and desire for more feed.</td>
</tr>
</tbody>
</table>
9.2. Feed Record Sheets:

9.2.1. The Function and Use of the Feed Record Sheet

The feed record sheets are used to track the daily amount of feed consumed by the fish and their feeding response. The feed record sheet is therefore filled in, on a daily basis because fish are fed daily. The information recorded is the calculated amount of feed required for each pond per day as well as the actual amount the fish consumed that day and the feeding response at each meal.

The feed sheet can be filled in various ways depending on one's feeding regime and the number of ponds on the farm. Therefore, if one feeds twice a day, two rows can be filled up each day, one for the morning feed amounts and the other with the afternoon feed amounts. If fish are fed once a day, then one row is sufficient (see figures 9.3. and 9.4. below).

Because all the units of the farm need to be fed each day, the feeding sheet is filled as a weekly sheet with a column at the start to record in the estimated daily amount of feed the fish in the pond will require that week. This enables the person feeding, to estimate the feed needs in advance how much feed the fish might consume as well as observe and assess trends in feeding at a glance. The farmer is therefore in position to plan when to purchase more feed and how much to purchase each time, because it is not good to store feed for more than four weeks on the farm (see section 6.5.).

It is easy to miss out important observations if all the information is not on a single sheet. Records should be set out in a manner that you can notice trends at a glance.

The amount of feed consumed is then to be totalled at each sampling and at the end of the cycle. Using the biomass data from the pond management record sheet, one can then calculate the interval and overall FCRs. It is important to calculate the FCRs at each sampling interval as this helps on monitor FCR trends and ensure that the FCR is managed within the recommended limits. Otherwise, it might get out of hand and at harvest the overall FCR will be above 2 when nothing can be done to remedy the situation and a loss will have already been made (see figure 9.2 above).
## HOW TO USE THE FEED RECORD SHEET

**FEED SHEET: Week of …………**

<table>
<thead>
<tr>
<th>Pond</th>
<th>Type of feed</th>
<th>Amount to feed</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
<th>Tot kgs</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**Feeding Response:**

- **E** – Excellent – Fish are very active and come to feed immediately. The feed is all consumed by the fish within 15 to 20 minutes of feeding in _grow-out_ ponds. Ideally a bag of feed in a _grow-out_ pond should be consumed within 5 minutes.

- **G** – Good – Fish are less active and come to feed over a longer duration. Feed gets consumed over a longer duration.

- **F** – Fair – Fish are sluggish but do consume about three quarters of the feed. However, they do so in over more than 30 minutes.

- **P** – Poor – When feed is applied, fish do not come to feed. More than three quarters of the feed administered is left over.

**Figure 9.3:** How to use the feed record sheet.
Example of a Properly Filled in Daily Feed Record Sheet

The daily feed record sheet can be filled in several ways:
1. it can be used to serve all the ponds on the farm for the specified week.
2. if one decides to use a single sheet for an individual pond, then specify the week at the start of each row
3. if the fish are fed more than once a day, one row may be used to record the actual amount fed in the morning and the next row the amount fed in the afternoon.

In all cases, in the 'week day' columns record exactly how much the fish actually consumed at that meal and the feeding response at that meal.

<table>
<thead>
<tr>
<th>FEED SHEET: week of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B</td>
</tr>
</tbody>
</table>

Or if fish are being fed twice a day for example, one row could be used for the morning feed and the lower row for the afternoon feed

<table>
<thead>
<tr>
<th>Feeding Response: E - excellent G - good F - fair P - poor</th>
</tr>
</thead>
</table>

Figure 9.4: Example of a Properly Filled in Daily Feed Record Sheet
9.2.2. Interpretation of the Feed Records.

Table 9.2: Interpretation of Trends in Feeding Response and FCR

<table>
<thead>
<tr>
<th>FCR Trend</th>
<th>Possible Causes</th>
<th>What Should I do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A] FCR is much lower than what is suggested by the feeding chart while at</td>
<td>1. Underfeeding. When underfeeding has been prolonged, in addition to low FCRs, at sampling, fish are likely to show poor condition and there will</td>
<td>a. Increase the feed ration. Determine the amount of feed to increase with the aide of the feeding</td>
</tr>
<tr>
<td>the same time the feeding response is continuously excellent</td>
<td>be slow and differential growth.</td>
<td>chart.</td>
</tr>
<tr>
<td></td>
<td>2. Loss of fish/Mortalities - there may be fewer fish in the pond than what one actually thinks. This is only true for the estimated interval FCR.</td>
<td>b. Then, feed by feeding until the fish appear to lose interest in consuming more food.</td>
</tr>
<tr>
<td></td>
<td>If this is the case, then at draining, the real FCR will be much higher.</td>
<td>c. Do a complete inventory, if possible, to ascertain exactly how many fish are in the pond and what</td>
</tr>
<tr>
<td></td>
<td>作</td>
<td>size they are. This requires draining the pond and transferring fish to another pond. This should be</td>
</tr>
<tr>
<td></td>
<td>作出</td>
<td>a last resort because the stress of moving the fish will add to the mortality.</td>
</tr>
<tr>
<td></td>
<td>作出</td>
<td>b. Determine the feeding ration based on response rather than the feed chart directly.</td>
</tr>
<tr>
<td></td>
<td>作出</td>
<td>c. Make sure ponds are stocked with fingerlings that are actually 'alive' and of the recommended size</td>
</tr>
<tr>
<td></td>
<td>作出</td>
<td>(5 g for grow-out ponds). Watch the way fish are handled and packed from the hatchery. Fish should be</td>
</tr>
<tr>
<td></td>
<td>作出</td>
<td>packed in bags with oxygen for transportation or transported in properly aerated or oxygenated tanks in</td>
</tr>
<tr>
<td></td>
<td>作出</td>
<td>adequate amounts of water.</td>
</tr>
</tbody>
</table>
### B] Increase (high) in FCR and reduced feeding response

<table>
<thead>
<tr>
<th>FCR Trend</th>
<th>Possible Causes</th>
<th>What Should I do?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Overfeeding.</strong> (Overfeeding can arise when there is a lot of natural food in the pond or few numbers of fish in the pond).</td>
<td>a. Reduce the amount of feed being given to the fish based on feed response. &lt;br&gt;b. Cut ration for about two to three days to get fish really hungry then give amounts based upon response &lt;br&gt;c. Check pond bottom under feeding area for leftover feed.</td>
<td></td>
</tr>
<tr>
<td><strong>2. Poor Feeding technique- trickling in feed and feeding more frequently than is required.</strong></td>
<td>a. Cut ration for about two to three days to get fish really hungry then give amounts based on response &lt;br&gt;b. The number of feedings to be given depends on the size of fish and ration size that fish is to get based on its percent body weight. Each ration should be about 1% of the fishes body weight. &lt;br&gt;c. The amount fed should be slightly less than the daily feed requirement (i.e. about 80 -90% of the full ration)</td>
<td></td>
</tr>
<tr>
<td><strong>3. Poor quality feed (both qualitative and quantitative) - e.g. Pellet size may be too big or small (feeding powder when fish are big), pellets disintegrating in water too soon, pellets too hard especially for catfish, rancid feed.</strong></td>
<td>a. Buy the correct type of feed for the fish being raised (i.e. protein levels, size of pellet) &lt;br&gt;b. Check the pellets at purchase. &lt;br&gt;c. Do not purchase and stock too much feed over a long period on the farm. Purchase enough to last about 4 - 6 weeks to ensure that fresh feed is used as much as possible. &lt;br&gt;d. Store your feed correctly to prevent it getting wet, mouldy or rancid. Feed should be stored off direct floors and walls on pallets, in a well ventilated room that does not leak, and has provision to prevent pest entry (rats &amp; bats).</td>
<td></td>
</tr>
</tbody>
</table>
### Chapter 9 – Production Records, Their Use and Interpretation

<table>
<thead>
<tr>
<th>FCR Trend</th>
<th>Possible Causes</th>
<th>What Should I do?</th>
</tr>
</thead>
</table>
| **C] Increase in FCR while feeding response remains fairly good** | 1. Pond may have surpassed its critical *standing crop* i.e., grow slowing down | a. Check inventory trends from pond records  
b. Reduce *stocking* densities |
| | 2. Feeding technique - *dumping* of feed. | a. Feed by response |
| | 3. The fish are getting larger so FCR increase is normal | Compare with feed chart to see if this is to be expected. |
| **D] Drop in feeding response** | 1. Changes in Water Quality causing the culture environment to become less favourable (e.g., drop in water temperature on cool days, reduced oxygen levels) | a. Do not increase feed at the next *ration* to compensate for the period when it was cold.  
b. Feed based on response - give the right amount for the *ration*. |
| | 2. Fish Falling Sick | a. Identify the cause |
| | 3. Cold weather | a. Reduce feed amount (cut the *ration* in half if the temperature drops from 28°C to 22°C for example). |
| | 4. A sudden but unseen loss of fish (e.g. theft). | a. Adjust feed amount by feeding by response. |
Summary Guidelines on Records and their Use

The objective of keeping records is to:
1. Monitor and evaluate performance,
2. Guide management, business and investment decision making,
3. The basis of the farm’s planning data.

The recommended production records are the:
1. Pond Record that tracks pond management and production details.
2. Feed Record Sheet that tracks feed use and feeding response

In combination, these records provide the data and information to enable one assess:
1. Pond management performance, notably:
   a. When pond is approaching critical *standing crop* or *carrying capacity*.
   b. Effect of management on water quality and production.
   c. *Stock control* - at any one time one can keep track of the numbers and sizes in the pond.
   d. Provides data to calculate net production, survival and *FCRs*.
2. Feed performance, notably:
   a. How much feed fish are actually consuming *vis-à-vis* estimated requirements.
   b. Trends in feeding response which enable early detection of changes in water quality and fish *health*.
   c. Provide data to calculate *FCRs*.

In addition farmers should keep records of:
   a. all the other inputs used for fish production (e.g. pond repairs, labour, transport, etc).
   b. accounts: expenditure and sales.

Also:
1. *Only write down known measures*, in case calculations are to be made and may need correction in the event that mistakes are made.
2. Avoid transferring information over and over as the likelihood of making and replicating errors increases. Information should be transferred not more than once. *Keep a pocket farm diary for writing facts (both figures and other observations)* while you work.
The appropriate information can then be transferred from these into the respective record sheets.

Records are kept for the benefit of the farm. It is in the farmer's own interest that records of pond management, feeding, expenses and sales are kept as recommended because they are the only means through which one is able to critically monitor, manage and evaluate production and profitability. Hence, be truthful in the record keeping. Record exactly what you have done or has occurred each time. For example, if one does not have a weighing scale and has therefore had to visually estimate average weight the fish harvested, when filing in the records sheets, record that the weight was estimated and not actually weighed. Falsifying production and sales records is a dis-service only to the farmer because the farmer shall not be in position to detect and correct mistakes if any.

**Remember !!** Farmers raising terrestrial animals can see and touch the animals they farm every day, any time. A fish farmer cannot. The only time a fish farmer can see his fish is at feeding time (if the fish have been trained to feed by response) and when sampling or harvesting. The only time a fish farmer can touch the fish they farm is at sampling or harvest time. Therefore, the only way a fish farmer can practically monitor trends in production, fish numbers, and changes in fish condition during the course of production is from the trends of the production records. *Keep them as accurately as possible*
Special Notes on other production options

A: Raising Catfish on Poultry or Livestock Offals.
These recommendations are based on the experiences of other farmers and trials conducted under the project.

Not all farmers may have access to feed. For those using offals (usually poultry processing wastes) remember:

1. Offals are mainly a source of energy to the fish. They have insufficient protein and have a high fat content. Therefore, manage your ponds for management level 3 (see section 5.3.1.3 for more details). Your carrying capacity will be lower than 1.8 kg/m².

2. In order to improve the palatability and digestibility, cook and mince the offals before use. If you cannot mince, cut into the smallest size you can.

3. You may feed the fish three times a week rather than daily. This is usually the choice of the farmer because:
   a. It reduces the number of trip to collect offals.
   b. It allows the farmer to feed all offals at once so they do not sit around in barrels and begin to spoil.
   c. Catfish take up about two to three days to digest the cooked and chopped offals.

4. Feed by response to help control the amount of organic matter added to the pond and size ranges of the fish.

5. Catfish fed offals only may suffer vitamin deficiencies. Stocking densities should be lower in ponds fed offals compared to ponds where fish are fed complete diet.

6. When fish are fed offals, water starts smelling foul as a result high organic loading and deterioration in water quality. The ponds therefore need flushing more frequently. Practice partial water exchange at least once every ten days if one is feeding thrice a week.
7. Check your FCRs. Feeding offals is a business decision. Even if you do not weigh the offals, you should know how many buckets you used (and hopefully the weight); how much each bucket of offals cost, and how many kgs of catfish you produced.

8. Some of the farmers who feed offals have observed that it is better to start feeding them when the fish are 100 g and above. Before then, they feed commercial pellets.

B: Raising Catfish on Farm-Made Feed.

Manage your ponds for management level 3 (see section 5.3.1.3 for more details). Your carrying capacity will be lower than 1.8 kg/m² because the diet will likely be incomplete in vitamins and is very likely to have insufficient protein. Farm-made feeds often result in FCR of about 4 or more.

C: Raising Catfish using water exchange

To have higher yields, of 20 to about 30 t/ha:

1. Make sure the pond has a water depth of 1.5 to 2.0 m. But not more than 2.0 m because of the risk of thermal stratification on cloudy and rainy days.

2. Begin to exchange water when the standing crop reaches about 15 T/ha.

3. Use only very high quality preferably floating feed.

4. Increase the rate of water exchange (flush with at least 50% of the pond volume daily).

The greater the water exchange, the higher the carrying capacity if the fish are fed a complete diet. Using incomplete diets is unlikely to result in higher carrying capacity because the water that is exchanged will wash out any natural food.

Note: The water flushed from the pond in this case should not enter directly into a public waterway. It should be used on agricultural land or passed through a wetland first.
D: Raising Catfish in Production Tanks (Raceways)

Limits achieved so far are:
1. In static water tanks, in Nigeria, the carrying capacity is reported to be about 15 kg/m$^3$. No information on water exchange or replacement was given but it is known that the more fish in the tank, the more water exchange is needed and the lower quality feeds require higher water exchange.
2. In Uganda, when water was exchanged at least once per day, and with constant aeration, the carrying capacity was 50-70 kg/m$^3$. Remember to dispose of the polluted water responsibly.

However, this is only possible using high quality, complete floating feed.

In Nigeria, the system works in some places because:
- construction costs are relatively low
- pumping costs are not included
- good quality fingerlings are available at reasonable cost (about 180 USh each)
- the price of high quality complete feed is about 1/3 the selling price of the catfish that are produced;
- selling size of the catfish is about 350-400 g, which usually means that the FCR will be lower than for a selling size of, say, 800 g.
- multiple tanks are used to cut management and labor costs, and cooperatives provide the loans for operating costs. One manager takes care of up to 150 tanks.

(see Miller 2007)
SECTION III:
PRODUCTION AND BUSINESS PLANNING
CHAPTER 10

RUNNING A FISH FARM AS A BUSINESS

The objective of commercial fish farming is to produce fish for sale and earn profits. Therefore, production should be planned from the onset to target identified markets. This means one should:

1. have the required product (size and form) available when the market wants it,
2. be able to produce adequate volumes to sustain targeted markets,
3. produce at a competitive price and profit.

10.1. Production Planning

When making a production and business plan for table fish, one should endeavor to answer the following questions beforehand.

1. Where is the market? - its location, what category of people are likely to buy the fish I produce, etc
2. What does the market want? - type of fish, how much, what size, how frequently, fresh or processed, etc.
3. What resources do I have? - number of pond(s), size of pond(s), water for production (quantity, quality, flow rates), feeds, labour, seed, etc.
4. From where and when should I source my seed and feed?
5. What is the quality of feed I intend to use? This is important because it limits possible FCRs, water quality and carrying capacity.
6. How much feed and seed shall I require?
7. What technology do I have at my disposal and which would be the best to adopt?
8. How frequently do I need to harvest for the market? (complete harvest/partial harvests)
9. How do I get my fish to the market?
10. What returns can I expect from the above?

The expected production from each pond can be projected beforehand using the template pond production plan with the aid of the feeding chart.
Below is an example of a production plan (See template pond production in appendix 11 for more details). Costs can then be added to the amounts derived. The production plan forms the basis of an enterprise budget. Note that the farmer should plan to harvest BEFORE carrying capacity is reached.

Box 6: Example of a Projected Pond Production Plan

A farmer's village market prefers catfish of about 800g. The farmer's pond is 1,000 m². The fingerlings he plans to purchase are on average 10 g each. Total alkalinity and hardness of the water were measured at 40 ppm each.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUANTITY</th>
<th>Unit Cost (USh)</th>
<th>Expected Total Cost (USh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pond Profile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pond Area</td>
<td>1,000 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Average Water Depth</td>
<td>0.9 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pond Water Volume</td>
<td>900 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Water Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Expected water need (replace losses)</td>
<td>1,372 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Stocking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Expected harvest (cc=2,000 kg)</td>
<td>1,800 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Targeted market size</td>
<td>800g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Number of fish to Stock</td>
<td>2,475 fingerlings</td>
<td>180</td>
<td>445,500</td>
</tr>
<tr>
<td>• Stocking density</td>
<td>1.8 fish/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. General Pond Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Estimated lime requirement</td>
<td>none</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. Feed Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Type of feed</td>
<td>Commercial Sinking Pellets (30% CP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Amount feed Required (assume FCR 1.8)</td>
<td>3,240 kg</td>
<td>1,000</td>
<td>3,240,000</td>
</tr>
<tr>
<td>6. Expected Duration of Cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Duration (weeks)</td>
<td>23 weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Duration (days)</td>
<td>161 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Expected No. samplings</td>
<td>5 times</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Final Harvest (3 seinings + drainage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Labour Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Family labour for feeding and daily maintenance</td>
<td>6 months</td>
<td>20,000</td>
<td>120,000</td>
</tr>
<tr>
<td>• 1 extra person for sampling &amp; harvests</td>
<td>9 man-days</td>
<td>3,000</td>
<td>27,000</td>
</tr>
<tr>
<td>8. Marketing Costs: Transport, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30,000</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td>TOTAL EXPECTED PRODUCTION COSTS</td>
<td></td>
<td></td>
<td>3,862,500</td>
</tr>
</tbody>
</table>

* costs are zero if no pumping is required to fill pond. In a well constructed pond, the only water loss should be from evaporation. Pond levels need to be topped up hence the extra water demand. Knowing how much water one requires per cycle helps one size farm reservoir for water supply to fish farms.

NB: For details on how to make above estimates in production plan, see appendix 11.
10.2. The Enterprise Budget

An enterprise is a separate business on a farm. For example, if a farmer is growing chickens, fish for food and fingerlings, each of these can be viewed as separate enterprises. Knowing the profitability of each enterprise allows the farmer to decide if a particular enterprise should be continued. For example if a farmer is not making much money, it may be because one enterprise is operating at a loss while others are actually profitable.

A quick enterprise budget exercise can help a farmer calculate the break-even price of their product to compare this with their expected selling price. For example in the pond production plan above, a total cost of 3,862,500 USh to produce 1,800 kg of catfish means that the farmer must sell at a price above 2,145USh/kg just to cover the production costs and this does not even pay back the land and farmer’s own labor.

Table 10.1 gives a sample enterprise budget for a 1,000 m² catfish grow-out pond fed nutritionally complete commercial sinking pellets based on data obtained during the USAID FISH project’s trials. It is important to note that other costs such as land, labour have not been included in table 10.1. Only the basic inputs have been costed in the variable costs, notably fingerlings and feed. Such land and labor are highly variable from farmer to farmer. If they are not included in the enterprise budget, then the profit is often called “returns to land and labor”.

The table 10.1. shows that catfish can be grown profitably. However, as opposed to what most farmers’ believe, it is not possible to regain all of one’s capital costs in the first production cycle. It takes 5 - 10 years to pay off one’s capital investment costs when land and pond construction are taken into account. When farmers ignore the cost of the pond, they often make poor decisions on management.
Table 10.1: Example Enterprise Budget for Single Pond Cycle for Static-Water Catfish Monoculture Fed Nutritionally Complete Commercial Sinking Pellets

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount (m²)</th>
<th>Unit Cost (USh)</th>
<th>Total Cost (USh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Capital Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>land</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pond (1,000m²)</td>
<td>1,000 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water channels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production Targets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Standing crop</td>
<td>1,800 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targeted average size at harvest</td>
<td>800 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival at harvest</td>
<td>85 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCR obtained</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major Variable Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerlings</td>
<td>2,475</td>
<td>180</td>
<td>445,500</td>
</tr>
<tr>
<td>Feed</td>
<td>3,151 kg</td>
<td>1,000</td>
<td>3,151,000</td>
</tr>
<tr>
<td>Hired Labour (taken from Box 6, previous page)</td>
<td></td>
<td></td>
<td>147,000</td>
</tr>
<tr>
<td>Interest on Loans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Variable Costs</td>
<td></td>
<td></td>
<td>3,743,500</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fish of average size</td>
<td>2,104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total weight of fish available for sale</td>
<td>1,683 kg</td>
<td></td>
<td>1,658.3 kg</td>
</tr>
<tr>
<td>Net Production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Revenue</td>
<td>1,683 kg</td>
<td>3,000</td>
<td>5,049,000</td>
</tr>
<tr>
<td>Income above variable costs</td>
<td></td>
<td></td>
<td>1,305,500</td>
</tr>
<tr>
<td>Net if amortized over 10 years</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Proportion of Variable Costs
- Fingerlings 12 %
- Feed 84 %
- Hired labor 4%

If we take the net return divided by the variable cost x 100, we have 34.8% “returns above variable costs” without taking into account the actual cost of the money used to pay for the production. If a person had to borrow 3,743,500 USh, the interest on this loan could be rather high, maybe as much as 27%, which would mean the farmer is working for the bank. The farmer would have to pay back 1 million USh and be left with only 300,000 for the family. The enterprise budget allows the farmer to plan in advance and compare options.
10.3. Farm Production and Business Planning

When one has more than one pond on the farm, one should plan overall production to meet the targeted market requirements. One can have more frequent harvests and sales of fish from the farm if one follows a split program. This concept is similar to that in poultry production where the days-old chicks first come to the brooder, then move to a growing unit and finally are split among various fattening units.

The considerations taken into account include:

1. **The frequency at which one needs to supply the market and the quantities required at each delivery.** For example, if the market requires 100 kg of fish per week, there is no point in constructing a 2,000 m² with the capacity to produce 3,600 kg. This is because when the pond is seined one is likely to harvest about 300 kg or more at each seining. In such a case, each time the pond is seined, one will have to return some fish to the pond because the market requires only 100 kg of fish per delivery. Repeated seinings and returning fish back to the pond, is costly and stressful to the fish and in the long run, negatively affects overall survival rates and growth performance.

   In addition, one will need to harvest about 36 times to get out all the fish. It will only be after about 36 weeks (about 9 months) that the pond is likely to be completely harvested. Therefore, for more than half of the time the pond is in production, it will be stocked at less than its full capacity with fish that are ready to market. Holding fish ready for market for 36 weeks is a rather long time and is an inefficient way of management that will surely result in high FCR and low profit. Therefore, in cases where the market requires small amounts of fish each time, it makes more business sense to have several small ponds rather than a few large ponds.

2. **The need to optimize space and use resources more efficiently.** Fingerlings only require about 10% of the pond area initially if a single in-out system is used. The rest of the space in the pond is unused, but the farmer still has to manage the entire pond. In fish farming, unlike crop production, you cannot look after a portion of the pond as you would a portion of your garden. In addition, catfish tend to feed more vigorously when they are at high density.
Therefore, it is preferable to have ponds of different sizes on a grow-out farm rather than a few extremely large ones. When the fish come in as **fingerlings** they are raised to stockers (for example, from 10 g to 50 g) in nursery ponds. Stock the stockers into grow-out ponds. Stockers can additionally be raised to sub-market size in a pond which can then be split out and reared to market sized fish in larger, fattening ponds (see figure 10.1 below). Space on the farm can therefore be used more efficiently. Having a split program also helps one track more closely, the number of fish being raised on the farm because each time the fish are transferred to a different unit, the previous pond is drained and a complete inventory done.

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**Figure 10.1:** Illustration of Options of a Split Production Program

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All-in-all, as a commercial farmer, one should ultimately aim at:

1. **Satisfying the Market Needs.** Plan management activities in a manner that ensures a steady supply of the right quality to the identified market, at the **frequency** the market demands. To do this, one must take into account one’s:

   a. **Resource Limitations**, notably land availability, money required for inputs before sales are made (cash flow),

   b. **Source of Capital.** For example, how frequently should I make sales and what should be the size of those harvests so that I do not feel the pinch of buying inputs for eight months before I can get some income. It is important to take this into account because,
credit facilities to cover operational (variable) costs for fish farming are costly and are currently not accessible for the majority of fish farmers in Uganda. Much of the investments farmers are making into fish farming are from their own savings.

Plan and schedule management activities in a manner that reduces time and costs as well as cash outlays. Be efficient in everything you do.

2. **Production Efficiency.** When running a fish farm commercially, the overall aim is to minimize production costs and optimize efficiency as well as returns. Practically this means:
   a. **Lowering FCRs to optimum levels.**
   b. **Lowering labour costs.** For example, sample all your ponds on the same day if extra labour is required.
   c. **Improving returns to land.** It should be profitable to use the land for fish farming. Use your space as efficiently as possible because land costs money and has a value as the major capital investment cost. Aim at getting the best production per unit area for the technology being applied.
   d. **Making and adopting the appropriate investment and management decisions.** A farmer should be in position to decide whether or not to increase the levels of production, when to do so and by what level production should be increased. The farmer should also be in position to examine whether or not it will be possible to achieve the desired level(s) production practically and profitably, with the resources available to him/her. For example, should production be increased by building more ponds, improving management, or simply deepening ponds to recommended levels? If you are not sure, try one pond first and compare the results.

10.4. **Setting Up and Running A Fish Farm: A Business Case Study.**

Imagine there are two farms, Farm A and Farm B. Both farms are of a similar size with about 5,000 m² water surface area for production. In both cases, their market can absorb 300 kg of 800 g live catfish to the local trading center on a weekly basis once a week. The market in both cases offered a farm-gate price of USh. 3,000 /= per kg fish, cash payment on supply. The trader would collect the fish from the farm each time to take to the market.
Farm A and Farm B have taken different strategies for their business. Farmer A has decided to construct a few large ponds because he perceives himself a large commercial farmer. Farmer B on the other hand, decided to construct several small ponds. Whose business is likely to be more successful and for what reasons? What are the advantages and disadvantages of each of their choices?

### 10.4.1. Investment Strategy

After identifying and verifying the market described, both farmers decided to invest in fish farming. They independently identified suitable land for fish farming that allowed for a total fish farm size of 5,000 m² pond water surface area. However, while farmers A and B have similar business interests, their investment plans differed. Table 10.2 below illustrates their investment plans and the following sub-sections discuss the effect of their plans on their fish farming business.

**Table 10.2: The Investment Plans of Farmer A and Farmer B**

<table>
<thead>
<tr>
<th>Farmer A’s Investment Plan</th>
<th>Farmer B’s Investment Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Self financing from personal savings.</td>
<td>1. Self financing from own personal savings.</td>
</tr>
<tr>
<td>2. Feels there is a need to rush because he does not want to miss the opportunity the market presents. After all he has all the cash at hand.</td>
<td>2. Wants to tap the opportunity market presents but, appreciates the fish need time to grow. Also remembers that market requires fish to be supplied to it weekly.</td>
</tr>
<tr>
<td>3. Goes full swing into commercial production, plans out and construct 3 large ponds of 1,650 m² each at once. Wants to do it big and earn big immediately. Not interested in small petty business.</td>
<td>3. Does not have adequate cash-at hand. So decides to build-up the farm step-by-step with smaller units.</td>
</tr>
<tr>
<td>4. After construction, plans to stock ponds all at once.</td>
<td>4. After planning, decides to construct 1 nursery pond and then over time, 7 small ponds to sustain market.</td>
</tr>
<tr>
<td></td>
<td>5. Decides to constructs a small nursery pond first, and then stock it as soon as it is completed. While fish are growing, starts a larger pond, and so-on; so as to be in position to have some sales early from which additional income can be obtained to top money saved for investment.</td>
</tr>
</tbody>
</table>
### 10.4.2. Production Management

Consequently, the two farms have different management strategies. Table 10.3 below illustrates the production management details of both farms.

**Table 10.3: Illustration of the Production Management Details of Farm A and Farm B.**

<table>
<thead>
<tr>
<th></th>
<th>Farm Business A:</th>
<th>Farm Business B:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ponds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Total Number of Ponds on the Farm</td>
<td>• 3</td>
<td>• 8</td>
</tr>
<tr>
<td>2. Sizes of Pond on the Farm</td>
<td>• 1,650 m² each</td>
<td>• 1 nursery pond of 45 m²; 7 ponds of 667 m² each</td>
</tr>
<tr>
<td>3. Total Water surface area for production</td>
<td>• 4,950 m²</td>
<td>• 4,714 m² (but more land is needed)</td>
</tr>
<tr>
<td>4. Pond Construction Criteria</td>
<td>• All constructed to standard with average water depth of 1 m.</td>
<td>• All constructed to standard with average water depth of 1 m.</td>
</tr>
<tr>
<td><strong>Stocking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Carrying Capacity of Ponds</td>
<td>• 2,970 kg each</td>
<td>• Nursery Pond: 81 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grow-out Ponds: 1,201 kg each</td>
</tr>
<tr>
<td>2. Size at Stocking</td>
<td>• 5 g fingerlings</td>
<td>• Nursery Pond: 5 g fingerlings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grow-out Ponds: 20 g</td>
</tr>
<tr>
<td>3. Intended Harvesting Size</td>
<td>• 800 g</td>
<td>• Nursery Pond: 20 g</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grow-out Pond: 800 g</td>
</tr>
<tr>
<td>4. Number of Fingerlings Stocked per pond</td>
<td>• 4,804</td>
<td>• Nursery Pond: 2,250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grow-out Pond: 1,800</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Production Cycle</td>
<td>• 30 weeks</td>
<td>• Nursery Pond: 4 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grow-out Pond: 26 weeks</td>
</tr>
<tr>
<td>2. Number of samplings per pond per month during course of production</td>
<td>• 1</td>
<td>• Nursery Pond: 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Grow-out Ponds: 1</td>
</tr>
</tbody>
</table>
### Chapter 10 – Running a Fish Farm as a Business

#### Farm Business A: Farm Business B:

| 3. Estimated FCR at end of cycle | 1.8 | Nursery Pond: 0.9  
|   |   | Grow-out Pond: 1.8 |

| 4. Survival Rates | 60 % | Nursery Pond: 80 %  
|   |   | Grow-out Pond: 85 % |

| 5. Estimated biomass at end of cycle per pond | 1,960 kg per pond | Nursery Pond: 32.4 kg  
|   |   | Grow-out Ponds: 1,224 kg |

#### Harvesting Schedules

**NOTE:** market requires 300 kg per week

| 1. Number of seinings for harvest before complete drainage | 5 per-pond before complete drainage | Nursery Pond: 0. All fish removed from pond at once.  
|   |   | Grow-out Ponds: 3 per-pond before complete drainage. |

| 2. Drain a pond completely on the farm once every. | Because ponds were stocked a month a -part, first pond drained after about eight months. | Nursery Pond: once a month  
|   |   | Grow-out Ponds: once a month |

| 3. Re-stock program on the farm | Each pond has a cycle of 1.3 per year so it is only possible to supply market consistently for about 4 to 5 months of the year. | Each month a pond supply’s that months market requirement. At the fourth harvest the pond is drained. In this case it is possible to supply the market 300 kg consistently per week right through the year. |

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*It is recommended that the nursery pond in this case has a harvest basin to which there is a fresh water supply because the pond is drained frequently to remove all the fish in order to stock the grow-out ponds. A combination of the seine and harvest basin can be used on the day of harvest. The seine being used before hand to reduce the number of fish in the pond before it is drained. Having the basin and using it correctly at draining reduces the stress on the young fish which result in increased survival during the next stage of growth (see appendix 2 for guidelines on how best to manage a catfish nursery pond).*
10.4.3. **Cash Flow Trends**

Once a farm is in operation, one needs to have cash-at-hand to buy the feed and *fingerlings* as required based upon one’s production and business plan. Managing cash-flow is important. One of the major constraints Ugandan farmers face when running fish farms as a business is cash-flow because the majority of them finance their operations from their personal savings. The set-up of one’s farm can have an effect on one’s cash-flow trends. Figures 10.2 and 10.3 show the effect the set-up of Farm A and Farm B has on the farmer’s cash-flow respectively.

![Figure 10.2: Trends in Cumulative Expenditure (Variable Costs) and Income (Cash-Flow) for Farm A](image)

**Figure 10.2:** Trends in Cumulative Expenditure (Variable Costs) and Income (Cash-Flow) for Farm A

Farmer A sells fish once a year over a period of between 4 and 5 months. While growing the fish farmer A has to pay for all the inputs. Therefore, for the first year of operation, farmer A needs to have cash enough from outside sources for 8 months until the revenue start coming in. Because all the revenues come in at once within a specified period, the farmer must be good at saving, in order to be able to successfully finance the second year of production to harvest. Such a farmer’s business is only financially more stable soon after sales, and is more susceptible to shocks as the income and expenditure gaps widens in the middle of the production cycle. At such moments, if farmer A has to pay for unexpected bills, he or she can easily end up in a situation whereby he/she cannot, for example, afford to buy the full amounts of feed required to complete a *production cycle*. 
Farmer B on the other hand, sells fish weekly and therefore, has revenue coming into the farm in smaller amounts but more frequently and regularly. During the first couple of years though, there is likely to be a strain on the amount of disposable cash-at-hand. This is because most of the revenues will immediately have to be turned in for re-investment and production. Each time revenue comes in however, it comes in with a proportion of the profit, and this progressively builds up. Consequently, over a time period, this farmer will have more cash-at-hand available to finance his/her operations. Therefore farmer B’s business, eventually becomes more stable and will be in a better position to survive the shocks in business. Farmer B, is likely to stay in commercial fish farming longer and expand with time if he/she so wishes.

10.4.4. Enterprise Budgets (Know expected expenses and revenues)
Table 10.4: Implications of the Investment Strategy on Costs and Returns

<table>
<thead>
<tr>
<th><strong>Pond Construction Costs: Farm A</strong></th>
<th><strong>Pond Construction Costs: Farm B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Because the ponds are large, the unit costs of pond construction are likely to be higher because soil will have to be moved over larger distances from within the pond. Such a farmer is more likely going to have to hire additional help to construct the pond.</td>
<td>Ponds are much smaller. Soil is moved a shorter distance. However, slightly more money is likely to be spent on making channels because more inlet and drainage channels to and from the extra ponds. One can get by, building smaller ponds, by depending on the family labor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Production: Farm A</strong></th>
<th><strong>Production: Farm B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Can only supply the market 300 kg per week for a total of 24 weeks of the year.</td>
<td>Is able to supply the market with 300 kg of fish 52 weeks of the year.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Marketing: Farm A</strong></th>
<th><strong>Marketing: Farm B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Each time fish is ready for the market, Farmer A will have to re-develop the market because 28 weeks later most of the previous clients will have found other suppliers.</td>
<td>In the long run, Farmer B is likely to have lower marketing costs because he/she is consistent in supplying the market. More customers will eventually come to depend rely on this farmer for fresh fish.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Transport Costs: Farm A</strong></th>
<th><strong>Transport Costs: Farm B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs transport to and from farm more frequently during the moments fish is being sold. The rest of the time can get away with only going into town once a month to purchase feed. It is costly for such a farmer to go in to town to purchase small amounts of feed on a weekly basis during the periods when there are no sales on the farm. (Unless of course, the farmer lives close by or has other business to do in town).</td>
<td>Goes to town weekly to take fish for sale. On the way back can return with supplies for the farm. Because sales are done on a weekly basis, one is able to purchase feed in smaller quantities without much implication on transport costs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Labor Requirements: Farm A</strong></th>
<th><strong>Labor Requirements: Farm B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>For periods when there no sales, labor is only for feeds, maintaining premises and sampling the ponds. Needs more labor when draining ponds to ensure all fish are removed before birds come in and harvest them all.</td>
<td>Ponds are smaller and therefore more manageable by one person and at most two persons during periods like harvesting, draining or undertaking minor repairs in pond in time for next cycle. Farmer B is also much busier because this farmer is continuously harvesting, feeding, draining, sampling and selling.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Earnings: Farm A</strong></th>
<th><strong>Earnings: Farm B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower turn-over therefore earns less per year from the same amount of land.</td>
<td>At the end of the year produces more but consequently spends more per year on feed and fingerlings. However, because of the higher turnover, in the long run, has a higher annual income.</td>
</tr>
</tbody>
</table>
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Table 10.5: Projected Annual the Enterprise Budget for Farm A and B

<table>
<thead>
<tr>
<th></th>
<th>Farm A</th>
<th>Farm B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Annual Production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Target</td>
<td>300 kg per week</td>
<td>300 kg per week</td>
</tr>
<tr>
<td>Weeks fish was supplied to market</td>
<td>24</td>
<td>52</td>
</tr>
<tr>
<td>Amount Fish Sold per Year (kg)</td>
<td>7,200</td>
<td>15,600</td>
</tr>
<tr>
<td>Unit Price of Fish/kg offered by Market</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Total Sales</strong></td>
<td>21,600,000</td>
<td>46,800,000</td>
</tr>
</tbody>
</table>

**Inputs Required During the Year**

<table>
<thead>
<tr>
<th></th>
<th>Farm A</th>
<th>Farm B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingerlings&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9,000</td>
<td>19,500</td>
</tr>
<tr>
<td>Feed Required (kg) (assuming an FCR of 1.8)</td>
<td>12,960</td>
<td>28,080</td>
</tr>
<tr>
<td>Other expenses, e.g. labour, transport, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Operational Costs**

<table>
<thead>
<tr>
<th></th>
<th>Farm A</th>
<th>Farm B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingerlings @ USh. 180/= each</td>
<td>1,620,000</td>
<td>3,510,000</td>
</tr>
<tr>
<td>Feed @ USh. 1,000/= per kg</td>
<td>12,960,000</td>
<td>28,080,000</td>
</tr>
<tr>
<td><strong>Total Operational Costs</strong></td>
<td>14,580,000</td>
<td>31,590,000</td>
</tr>
<tr>
<td>Returns above Operational Costs</td>
<td>7,020,000</td>
<td>15,210,000</td>
</tr>
</tbody>
</table>

<sup>a</sup> Farm A has on average 1.3 cycles per year giving time for the complete harvest and drainage of the pond as well as for pond repairs/maintenance and preparation before the next stocking. In the case of Farm B, having a nursery pond as well as several small ponds, implies that fingerlings are purchased every month (for more details see table 10.5 above).

In the long run, Farm B uses its ponds more efficiently and has the potential to be a larger business compared to Farm A, yet both have the same acreage of land. This is an example of how starting small, if done right, can result into a more productive and sustainable business. However, other costs should also be taken into account as well as specific issues such as location, etc. before making the final decision on how to establish and run your business. The above example is not necessarily the only option nor may it be the best option for you.

10.4.5. Increasing Overall Farm Income

When running a farm, the overall farm objective should be to optimise all the resources at your disposal in order to earn the most you can in a manner that does not compromise the viability of the establishment. Therefore, for example, one should ask themselves how else can I earn extra from the farm and not just from my pond production?
Well constructed and maintained fish farms actually do look beautiful. Some farmers in rural areas allow people come to the farm to take their wedding pictures at a fee. Some set aside a small section of the farm as a recreation centre, open only on specific days or only for booked up occasions. Schools also take children to visit farms as part of the local geography lessons or for recreation for the children. If one decides to open up the farm occasionally to earn more money, one needs to assure that the premises are safe (have well built bridges over water channel not just flimsy planks of wood). In addition, if the fish farm is the primary business, then associated secondary businesses should not hamper the farm’s production goals. For example only open up the farm on specific days as you might need to have extra security depending on where you are, considering the amount of attention or labour you might require to attend to the guests, etc.

Be creative and attempt to get the best returns from the resources that you have. Do not ignore additional costs associated with additional uses of your ponds.

10.5. **Choosing a Production Technology**

The choice of one’s production technology should be selected based on the market’s requirements, and the resources one has available.

*For example:* The market a farmer has identified would like 300 kg of whole fresh catfish per week. The farmer has been presented with three different options for producing this fish, namely:

- a. System A: based on feeding commercial sinking pellets
- b. System B: based on feeding farm-made feed
- c. System C: based on feeding poultry offals.

The farmer does not have access to power and therefore intends to do the production in static water ponds without aeration. What option would should the farmer select for growing his/her fish?

When presented with such information the following are among the questions that should be answered:

- a. What is the *carrying capacity* of each system?
- b. What is the expected *FCR* if I were to follow the recommended management practices for each system?
- c. Where would I source the inputs required? Are they easily accessible to me?
d. How much would these inputs cost?
e. What is the expected survival rate in each case?
f. What price is the market offering me for the fish I shall produce?
g. How long is the expected production cycle in each case?
h. How much space shall I require?

The Decision Process. The following is an example of how one can go about making a choice of what technology one should adopt based on their specified production objectives.

In order to produce 300 kg of whole catfish on a weekly basis one would require one nursery pond and seven grow-out ponds if a pond is to be drained monthly on the farm. This is so that each pond is seined not more than four times before it is finally drained to allow for efficient use of ponds.

A. Critical Standing Crop: If each week the market requires 300 kg, then the farmer will need to have 1,200 kg of fish ready to market in each pond each month. This implies each of the seven grow-out ponds should have the capacity to hold at least 1,200 kg of fish at the end of the production cycle (i.e. the carrying capacity of the pond should be well above 1,200 kg so that fish growth has not slowed down before the fish attain market size). However, because of the differences in the qualities of the different feeds, the carrying capacity of the ponds under each of the systems of management will inherently be different (Chapter 5.3 for more details). Therefore, in order to be able to have the same quantity of fish ready for market each time, the optimum size of grow-out ponds will vary for the different systems. In System C whose feed has the highest FCR the grow-out ponds should be about 2,400 m² whereas for System A they need be 667 m² only. This implies that if one chooses to adopt system C, he/she would have to spend more money on pond construction (see table 10.6 below).

B: The FCR: Different feeds also present different FCRs as is shown in table 10.6 below. Hence, though a feed may cost less than another, if the FCR is high, it implies one would need more of the less costly feed to feed the fish appropriately for optimal growth. Hence, the question to actually be answered is ‘Which of the different options is likely result in the lowest cost of feeding my fish?’ For more details see section 6.3.3.
Chapter 10 – Running a Fish Farm as a Business

C: Survival Rates. The survival rates under the different systems is likely to be different depending on the quality of feed, management practices and their effect on water quality as well as the fish nutritional status. With commercial sinking pellets farmers have obtained survival rates between 85-90%, farm-made feeds 40-60% and with offals about 20-40% (USAID FISH Technical Reports). One needs to compensate for expected mortality when stocking. Therefore, if one expects a survival of 60%, one will need to stock 40% more fish than was calculated for, which may in turn also have an effect on the desired pond size. In the example illustrated in table 10.6 below, the same survival rates are used for example purposes only. Every farmer should strive to get the highest survival rate from whatever system of management they use.

D. Price Offered by the Market. The ultimate question is “For the price offered by the market, which of the systems is most profitable if the recommended management practices for each of the system are followed?”. The example in the table gives a farm-gate price of USh. 3,000=/=. If it were higher or lower, which option would be most viable or would it be worth it growing catfish for sale?

There may be other factors likely to affect production, costs and returns not discussed in this example. Whatever choice you make, always adjust your system of production and selling price to get the best total profit achievable. Keeping records and track of your performance will help you do this.

Stop and Think!!!!!!

Sit down. Critically analyze the different options presented to you before deciding to farm fish commercially.

Be careful not to lose money.

If you think raising catfish will not be profitable, then change to another species of fish or another more profitable enterprise. Do not insist on growing fish for the sake of it unless you are doing it as a hobby.

Remember, the cost of seed should be about 20% or less of your variable costs if one is using feed as a major input into commercial fish farming.

Know that intensifying (meaning producing more fish per unit area) usually leads to LOWER profit margins. However, there is usually an even greater increase in volume of sales and therefore, greater total net revenue to the enterprise.
### Table 10.6: Illustrates the Analysis Procedure for Selecting a Suitable Production System for a Given Market

<table>
<thead>
<tr>
<th>Item</th>
<th>System A (com. Pellets)</th>
<th>System B (farm feed)</th>
<th>System C (offals)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Details</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Critical standing crop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tons/ha</td>
<td>18</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>kg/m²</td>
<td>1.8</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>B. Ponds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 nursery pond each (m²)</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>7 grow-out ponds each (m²)</td>
<td>667</td>
<td>1,200</td>
<td>2,400</td>
</tr>
<tr>
<td>total pond area required (m²)</td>
<td>4,714</td>
<td>8,445</td>
<td>16,845</td>
</tr>
<tr>
<td>C. Stocking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targeted market size (g)</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Size of fish at stocking (g)</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>No. of fingerlings to stock per pond</td>
<td>1,650</td>
<td>1,650</td>
<td>1,650</td>
</tr>
<tr>
<td>that means fish/m²</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>total number of fingerlings purchased</td>
<td>11,556</td>
<td>11,550</td>
<td>11,550</td>
</tr>
<tr>
<td>4. Harvest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated Survival Rate (%)</td>
<td>88</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td>Total number harvested</td>
<td>1,453</td>
<td>1,452</td>
<td>1,452</td>
</tr>
<tr>
<td>Total kg harvested and sold per grow-out pond</td>
<td>1,162</td>
<td>1,162</td>
<td>1,162</td>
</tr>
<tr>
<td>Total quantity of fish sold (kg)</td>
<td>8,135</td>
<td>8,131</td>
<td>8,131</td>
</tr>
<tr>
<td>5. Feed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCR (amount of feed to produce a kg of fish)</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total Amount feed Consumed (kg)</td>
<td>14,643</td>
<td>32,525</td>
<td>48,787</td>
</tr>
<tr>
<td><strong>COSTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Unit Input Costs (Ush.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pond construction (including channels and piping) (shs/m²)</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>fingerlings (shs/fingerling)</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>feed (shs/kg)</td>
<td>1,100</td>
<td>950</td>
<td>500</td>
</tr>
<tr>
<td>fish for sale (shs/kg)</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>B. Investment Costs (Ush)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pond construction</td>
<td>14,142,000</td>
<td>25,335,000</td>
<td>50,535,000</td>
</tr>
<tr>
<td>C. Variable Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerlings (one calendar year)</td>
<td>2,080,040</td>
<td>2,079,000</td>
<td>2,079,000</td>
</tr>
<tr>
<td>Feed</td>
<td>16,107,826</td>
<td>30,898,560</td>
<td>24,393,600</td>
</tr>
<tr>
<td>Total Variable Costs</td>
<td>18,187,865</td>
<td>32,977,560</td>
<td>26,472,600</td>
</tr>
<tr>
<td>Total Sales</td>
<td>24,405,797</td>
<td>24,393,600</td>
<td>24,393,600</td>
</tr>
<tr>
<td>Profit (above variable costs)</td>
<td>6,217,931</td>
<td>-8,583,960</td>
<td>-2,079,000</td>
</tr>
<tr>
<td>Profit if amortize ponds over 10 Years</td>
<td>3,389,531</td>
<td>-13,650,960</td>
<td>-12,186,000</td>
</tr>
<tr>
<td>Proportion Variable Costs (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fingerlings</td>
<td>11</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>feed</td>
<td>89</td>
<td>94</td>
<td>92</td>
</tr>
</tbody>
</table>
Summary Guidelines for Running a Fish Farm as a Business

1. Know your market before you begin the business. Keep in touch with the market even during production.
2. Expect the market to change over time; sometimes you can help it to change to reduce your production costs. For example, getting the customer to accept a smaller size.
3. Be smart – start small and then expand only if you are making money or if you can be sure that expansion will result in greater profits. Sometimes, expansion merely increases losses.
4. Keep records as recommended. Analyse and use your records continuously to help you evaluate your performance and make production as well as business decisions.
Why some Fish Farmers Succeed

1. Identify their business opportunities and markets beforehand.
2. Tailor their production to meet the market requirements in a profitable and reliable manner.
3. Invest wisely, step-by-step. Start small and build up only if they are making profits. Do not think of expanding (build more ponds for production) if/when they realize they are making losses.
4. Are particular about where they source advice from and whom they select as advisors. Select those with a proven track record (see appendix 11).
5. Do not cover up their mistakes but rather learn from them as well as from other farmers’ mistakes.
6. Keep and use their records. Track their expenditure and losses.
8. Use the best feed locally available to them correctly, closely monitoring their FCRs as they do.
9. Owners are involved in the running and/or management of the farm.
10. Invest and manage their farms based on the market opportunities and their resource limitations.
11. Proper siting of the farms and adopt appropriate production technology.
12. Sell their fish to the market as soon as they can and appreciate turnover.
13. Honor promises to their customers, even if occasionally it means they may have to make a no-profit sale or replace fish at no charge.
14. Are able to analyze their farm data themselves and use the data they obtain to assess the farms production and economic performance.
15. Use their own data as the primary basis for making management and investment decisions.
APPENDIX 1. Freshness Grading Scheme for Catfish

<table>
<thead>
<tr>
<th>Grade</th>
<th>Extra</th>
<th>A</th>
<th>B</th>
<th>C (unfit)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skin</strong></td>
<td>Bright, shining</td>
<td>Waxy, slight loss of bloom</td>
<td>dull</td>
<td>Dully, dry, gritty</td>
</tr>
<tr>
<td><strong>Outer Slime</strong></td>
<td>Transparent</td>
<td>milky</td>
<td>Yellowish-gray, some clotting</td>
<td>Yellowish and clotted</td>
</tr>
<tr>
<td><strong>Eyes</strong></td>
<td>Convex black pupil,</td>
<td>Plane, slightly opaque,</td>
<td>Slightly concave, graying pupil,</td>
<td>Completely sunken, gray pupil, opaque</td>
</tr>
<tr>
<td></td>
<td>translucent cornea</td>
<td>translucent cornea</td>
<td>opaque cornea</td>
<td>discoloured cornea</td>
</tr>
<tr>
<td><strong>Gills</strong></td>
<td>Bright red, mucus</td>
<td>Pink, mucus slightly opaque</td>
<td>Gray-white, mucus thick and opaque</td>
<td>Brownish, mucus yellowish gray and clotted.</td>
</tr>
<tr>
<td></td>
<td>translucent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peritoneum</strong></td>
<td>Glossy, brilliant,</td>
<td>Slightly dull, difficult to tear from</td>
<td>Gritty, fairly easy to tear from flesh</td>
<td>Gritty, easily torn from flesh</td>
</tr>
<tr>
<td></td>
<td>difficult to tear from</td>
<td>flesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>flesh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gill and internal odours</strong></td>
<td>Fresh, smell of pond water</td>
<td>Neutral odour</td>
<td>Musty odour</td>
<td>Fruity and/or sulphide smell</td>
</tr>
</tbody>
</table>

Adapted from Connell, 1995.
APPENDIX 2. Summary Guidelines on How Best to Manage a Secondary Catfish Nursery Pond

**Pond Preparation.** Dry the pond bottom for about 2 weeks to ensure fish not harvested, pathogens, etc are killed off. Excess bottom mud, weeds or any other debris are removed from the pond. During this time reconstruct damaged pond levees using the bottom mud removed. The latter is important to ensure there are no hiding places for predators (shooters inclusive) within the pond and to enable one better manage pond environmental conditions. Ensure inlet is properly screened with a fine sock. Ensure outlet is screened with a cone mesh.

**Liming the pond.** The major objective of liming nursery ponds is to kill any fingerlings from the previous cycle that might have not been harvested, potential predators and pathogens which might predate upon the young fry or become sources of infection to them. Therefore, quick lime or hydrated (builders) lime are recommended at a rate of 1,000 kg/ha and 1500 kg/ha respectively. Spread builders lime uniformly across the pond bottom paying extra attention to puddles of water that fail to drain or in places where fish might hide. Ensure pH gets up to 11. Liming to improve water hardness is recommended if the water hardness is 25 mg/l or less using agricultural lime.

**Pre-Stocking.** Only prepare to stock the pond once the pH has gone down to 7. This may take several days (normally 5 to 7 days). If the pond pH is still high wait an extra day or two for it to drop to about 7. The day before stocking, pour old diesel or some old vegetable cooking oil mixed with a bit of soap over the pond surface to kill off air-breathing insects, such as backswimmers, scorpion larvae that predate upon the young fry. Also remove any mats of frog eggs if any. Ensure that the entire water surface is covered with the oil. It is better to do so when there is minimum wind. Stock the pond the following day or later in the day once you have observed that the oil have evaporated off. The pond must be stocked as soon as possible before any potential predators establish themselves. The estimated carrying capacity for static water non-aerated catfish nursery ponds fed complete commercial diets is 5 tons/ha. (0.5 kg/m²).

**Daily Pond Management.** The night of stocking, with a torch, walk round the edge of the pond to check that the young fry have survived and are active. Check the pond daily. Continuously remove any mats frog eggs, dead fish that might come up to the surface. Record mortalities and bury all dead fish, frogs or their eggs away from the pond.

**Feed** the recommended feed based on response. Ponds should be fed at least three to four times a day at the rate of recommended by the feeding chart. Feed fish by response only. Keep area around pond clean and well slashed to reduce hiding places for predators.

**Harvesting.** Harvest the pond after about 4 weeks. Pass a seine through a couple of times before finally draining it to remove fish left in the pond.
APPENDIX 3. BMPs for Catfish Seed Production

The primary objective of a seed producer is to produce a fish that:

(i) is alive,
(ii) in good condition, i.e. physically as well as physiologically,
(iii) can survive and grow well in a grow-out establishment,

In order to achieve the above, the seed producer should be in position to:

1. Ensure good water quality for 'all stages of development' on the farm based on their specific requirements.
2. Provide proper and adequate nutrition for 'all stages of development' on the farm based on their specific requirements.
3. Stock as well as manage all production units on the farm based on each units' carrying capacity as well the specific requirements of the development stage being reared within each unit.
4. Use only eggs and milt of good quality for seed production.
5. Handle fish in a manner that minimizes stress, disease spread and mortality during routine and other procedures. The major routine procedures in catfish seed production where fish are handled include; spawning, sorting and grading, conditioning, harvesting, transfer and packaging fish for live transportation. Thus, handle fish at all times within good quality water, taking note of especially dissolved oxygen levels and temperature variations. Therefore, the farm should have facilities and tools that allow for this, notably units for holding fish live, appropriate nets of the right size (notably scoop nets and seines), harvest basins, functional units for aeration and/or oxygenation as well as for packing fish in bags with oxygen.
6. Sanitation and hygiene. Have and observe a health management plan that specifies the farms protocols for disease prevention, management and control with a focus on prevention of disease conditions within the hatchery/nursery as well as the spread to out-grower farms. This includes procedural details for all activities on the farm such as restricting use of nets, etc to specified areas/production units, water quality limits, minimal feed standards that ensure proper and adequate nutrition to the fish, handling and holding fish for whatever reason in a stress-free manner, chemicals and procedures used to disinfect production units, dips given fish (salt/potassium permanganate) before transfer to other units within the farm and out-of-farm, etc. All seed leaving the farm to out-growers should be dipped in 2% potassium permanganate solution to prevent spread of any external pathogens, especially if these are to be stocked in cages.
7. Routinely sorts and grades fish on a regular basis to ensure uniform sizes in the various production units.
8. Keeps hatchery records based on batches and lots of fish produced as well as uses hatchery records to monitor and evaluate production, fish health and general farm performance.
9. Can supply seed of good quality - alive, required size, uniform size, good condition, stress and disease free to the client; as well as package them as recommended in appendix 4 for live fish transportation for the client.

* ‘All stages of development’ on the farm refers to brood stock, eggs both unfertilized and fertilized eggs under incubation, newly hatched larvae, larvae, fry and fingerlings.
APPENDIX 4. Recommendations for Packaging Live Fish for Transportation

Package only:
1. Fish that have been conditioned in good water quality as recommended for at least 48 hours.
2. Fish that are in good condition and healthy; fish that are alert and active, look bright, have no physical deformities, no signs of disease, are of the right size and of uniform size.

A. Packaging in Bags for Live Transportation.
1. Of a 300-400 gauge plastic tube. This gauge of plastic is recommended because it is thick enough to withstand pricks from fish fin and is pliable enough to be folded over and tied in a close knot tight enough to prevent loss of air.
2. Cut off about 3 meters from the roll and tie a simple reef knot half-way so that finally the packaging will be double layered. 3 meters is cut so that the final length of the package after tying is about 1 meter. Having a double layer is done to safeguard against loss of air in the event of any eventuality resulting in a puncture of one of the layers, especially of the inner layer.
3. Set the tied bag in a basin or basket, open it up and fill it a third -way with water (10 – 15 litres of water depending on the length). The temperature of the water placed in the bag should as much as possible to equal to that of the holding water or not more than 2 °C above or below the holding water. Add some salt (magadi salt can be used) at the rate of 0.05% of the volume of water contained in the bag. Stir the salt in and ensure it is properly dissolved before fish are added into the bag.
4. Add the fingerlings. Add fingerlings at the rate of 0.5 to 1 kg total biomass for every 10 litres of water into the bag. The lower value should be used when fish are 5 g in size or less because the smaller fish have a higher metabolic rate. Do not exceed 1 kg for every 10 liters of water for fingerlings.
5. Immediately close the inner bag over and squeeze out all the air in the bag that is above the water.
6. Insert the delivery tube from the oxygen cylinder into the bag while still holding the top close to prevent air entering the bag.
7. Release oxygen into the bag and fill the bag with oxygen. Ensure that the amount of air above the water column is at least about twice the column length of the water.
8. Twist the top of the inner bag tight as you pull out the delivery tube from the cylinder. Twist tight, fold the twist over and tie the fold tightly in place using a rubber band from an old tyre tube.
9. Tie the out bag in a similar manner as in step 7 above over the inner tube.
10. Place the sealed bag in a cardboard box, bucket, or within any container that can provide it support and protection from puncture during transportation.

NB: Once fish have been placed into a bag, that bag must immediately be filled with oxygen and tied before fish are added into another bag. Never place fish into a bag and go on to do something else or add fish to other bags before the previous bag with fish is properly filled with oxygen and tied.
**B. Packaging in Tanks for Live Transportation.**

1. Calculate the volume of the tank.
2. Fill it with water to about two-thirds. At salt rock or magadi salt at a rate of 0.05% of the total water volume. Stir the salt in and ensure it is properly dissolved before fish are added into the tank.
3. Set in the aeration unit into the tank and turn it on.
4. Add the fish into the tank at a rate of 0.5 to 1 kg of fish for every 10 litres of water. The lower value should be used when fish are 5 g in size or less because the smaller fish have a higher metabolic rate. Do not exceed 1 kg for every 10 liters of water for **fingerlings**.
5. Remember, the fish added will displace a volume of water equal to their weight. This should be taken into consideration when determining how much fish can actually be transported in a tank of a certain volume.
6. Cover the tank once the fish are in the tank with a solid and keep it covered during the course of transportation. The lid prevents not only water from splashing out of the tank but also excess oxygen escaping to the atmosphere.
7. Check the water temperature and oxygen readings before you set off. If the oxygen levels are stable and above 5mg/l of dissolved oxygen, the flow-rate of oxygen into the tank can be reduced. Monitor oxygen levels and fish behavior frequently during the course of transportation. If the dissolved oxygen levels keep falling fast to below 4 mg/l, then increase the oxygen flow rate.

**N.B.** For long distance travel likely to exceed eight hours, zeolite packs can be added to both transport bags and tanks to absorb any excess ammonia that might be released by the fish.

**Examples:**

**Example 1. Calculating How Much Salt to Add in a Certain Volume of Water.**

A container for packing fish contains a volume of 10 litres of water in which the fish shall be added to for transportation. How much salt should be added if the recommended amount is 0.05% of the volume of water in the bag or tank?

\[
\text{Amount of salt to be added} = 0.05/100 \times 10 \text{ litres of water} = 0.005 \text{ kg of salt}, \text{ which is equivalent to 5 g of salt (0.005 kg x 1,000g = 5g)}
\]

**N.B.** Calculate the amount of salt required based on the actual amount of water in the container and not based upon the size of the container.

**Example 2. Estimating How Many Fingerlings can Safely be Accommodated for Transportation in a Tank.**

A farmer has a 300 litre capacity tank and intends to transport 50,000 catfish fingerlings averaging 10 g each. How many fingerlings should be placed in the tank if they are to be transported with minimum stress under aeration?

**Step 1:** Calculate the Total Fish Biomass that is to be Transported.

The total fish biomass to be transported is:

\[
\begin{align*}
&= 50,000 \times 10g \\
&= 500,000 \text{ g} \\
&= 500 \text{ kg of catfish fingerlings} \text{ are to be transported.}
\end{align*}
\]
500 kg of fish will displace an equivalent amount of water. Therefore, if 500 kg fish is placed in a container with water, 500 kg of water, (which is equivalent to 500 litres of water) will be displaced. 1 kg fresh water approximately equals 1 litre of fresh water. Therefore, if 500 kg of fish are placed in a 300 litre capacity tank that is full of water, all the water in the tank will be displaced and spill out of the tank. So a 300 litre tank is too small to carry 500 kg of fish at once.

The maximum holding capacity (of both fish and water) that can be contained within a 300 litre capacity tank is about 270 litres volume allowing for some extra free space to prevent spill-over.

**Step 2: Calculating the Maximum Number of Fingerlings Can Actually be Accommodated in the tank.**

Of the maximum holding capacity, 50 - 60% should be water, therefore, the tank should be filled with about 170 litres of water.

The amount of salt added to the tank in this case should be,

\[ \text{salt} = 0.05\% \times 170 \text{ litres of water} \]

\[ = 0.085 \text{ kg or 85 g salt} \]

The amount of fish that can be loaded into the tank should be equivalent in weight to the amount of volume left, that is:

\[ = 270 \text{ litres} - 170 \text{ litres} \]

\[ = 100 \text{ litres}. \]

Thus, about 100 kg of fish can be loaded because 100 kg fish will displace about 100 kg of water. 100 kg of fresh water is equivalent to 100 litres of fresh water.

Hence, because the average weight of the fingerlings being transported is 10 g, the number of fish that can actually be loaded is:

\[ = \frac{100 \text{ kg} \times 1,000}{10g} \]

\[ = 10,000 \text{ catfish fingerlings} \]

*can safely be loaded* into a 300 litre capacity tank for transportation under aeration.
APPENDIX 5.  **Catfish Feeding Chart for Pond Grow-Out**

(For ponds fed nutritionally-complete commercial sinking pellets)

<table>
<thead>
<tr>
<th>Weeks in production</th>
<th>Fish Size (g)</th>
<th>Growth (g/day)</th>
<th>Daily Feed (% BW)</th>
<th>Daily Feed/Fish (g)</th>
<th>est FCR</th>
<th>Type of feed Protein %CP - size (mm)</th>
<th>Number of Feedings/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Recommended Size at Stocking</td>
<td>*1 10</td>
<td>0.5</td>
<td>5.0</td>
<td>0.5</td>
<td>1.0</td>
<td>36-3</td>
<td>4</td>
</tr>
<tr>
<td>2 14</td>
<td>0.6</td>
<td>4.7</td>
<td>0.7</td>
<td>1.1</td>
<td>36-3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3 23</td>
<td>1.2</td>
<td>4.6</td>
<td>1.0</td>
<td>0.9</td>
<td>36-3</td>
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Notes on Use of Catfish Feeding Chart

Disclaimer
The growth chart only holds true if good management practices are followed for fish production in ponds. Fish will not grow as fast as this chart predicts if:

1. The pond is poorly constructed and is too shallow (Recommended average pond water depth is 1 meter).
2. The pond is not stocked based on its carrying capacity, and instead is "overstocked", meaning too many fish that require more feed than what the pond can sustain.
   (i) The carrying capacity of a 1,000 m² pond for catfish is about 2,000 kgs of catfish but it is best to plan to harvest before growth slows too much, say about when the pond reaches 1,800 kgs
   (ii) The stocking rate can be calculated as follows:
   \[
   \text{The Number to Stock} = \text{Carrying Capacity or expected harvest kgs/Desired Market Size} + 10\%
   \]
3. Fish escape from the ponds due to poor construction or unprotected pond inlets and outlets.
4. The pond water quality is bad or water temperature in the pond is lower than 26°C.
5. Water is allowed to continuously flow through the pond. It is recommended that grow-out production ponds are managed as 'static water' systems. Continuously allowing water to flow through washes away the nutrients that stimulate pond productivity and lowers pond water temperatures. This is especially true with tilapia. It is less of a problem with catfish. As the pond reaches its carrying capacity for static water and there are no immediate possibilities for harvesting or reducing the pond biomass, good water quality conditions can be maintained by exchanging about 50% of the pond water daily with good quality water.

Feed based on the fishes Feeding Response. The feeding chart is only a guide

Please Note: Do not feed more than 20g of feed /m² per pond per day in static water ponds; otherwise, the organic loading will be too great for the pond to assimilate and the fish will die.

How to Use the Feeding Chart.
The feeding chart is a guide to help you:
(i) Estimate how much feed fish might require, especially, if you have no actual weights from sampling.
(ii) Compare the performance of your fish and feeding regime. Target your overall FCR at harvest to be no more than 2.
(iii) Make projected production plans.
(iv) Back calculate the standing crop in the pond (see examples on next page).
Estimating Feed Requirement
1. To calculate the estimated total amount of feed the fish in a pond might require per day:
   \[ \text{Fish Size (g)} \times \text{Daily Feed (% BW)/100} \times \text{the total number of fish in the pond} \]
   (i) Base the estimate of fish size on size at weeks in production
   (ii) If you have actually sampled your fish and know their average size, then it is better to use this figure

2. To calculate the amount of feed to give at each meal:
   \[ \text{total feed requirement for the day (calculated in 1 above)/Number of Feedings/Day} \]

Read the number of feedings per day from the same row as the estimated fish size.

Note: Even after calculating how much feed the fish may require, the actual amount of feed fed to the fish depends on their feeding response. This is because fish might require more or less feed than calculated depending on their condition and the conditions in the pond that day.

Estimating Standing Crop Based on Feed Consumption
Example: A pond was sampled and the fish were found to have an average weight of 400g. The farmer feeds 4 kgs of feed every day and it seems the fish eat it all when the farmer feeds by response. What is the total fish weight (biomass) in the pond?
   i) At that size and based upon the feeding chart, fish eat about 1.8\% of their body weight per day. To calculate the estimated biomass,
      \[ \frac{\text{total amount of feed consumed each day}}{\text{expected daily feed ration per fish (% body weight)}} \]
      \[ = \frac{4 \text{ kg}}{0.018} \]
      \[ = 222 \text{ kgs of fish in the pond} \]

   ii) However, the farmer could be underfeeding, so it is possible too that the fish might only be getting 1\% of their body weight. In this case therefore,
      \[ \frac{4 \text{ kg}}{0.01} \]
      \[ = 400 \text{ kg is about the maximum biomass of fish estimated in the pond.} \]
APPENDIX 6. Effect of Changes in FCR and Fingerling Cost on Profit Margins

Assume:
1. Catfish were raised in a pond of 1,000 m² from 10g to 800g.
2. The estimated critical standing crop of the pond was 1, 800 kg.
3. Therefore 1,800/0.8 +225 = 2475 fingerlings were stocked.
4. At harvest the survival rate was 85%.
5. Total weight of harvest (biomass harvested) = 1,683 kg.
6. The farm gate price of the fish harvested is 2,800 USh./kg.

If,
1. Feed Cost was 1,000/= USh./kg, and
2. Cost of Fingerlings was USh. 170/=.
3. Cost of fish harvested was 2,800 USh./kg, then total amount earned = USh. 4,712,400/=.

What Shall Be my Profit if:

A: My FCR changes but the cost of my Feed and Seed are constant as mentioned above.

Table A:
Effect of Reducing FCR on Profit Margins

<table>
<thead>
<tr>
<th>FCR</th>
<th>Amount Feed to Feed a kg of Fish</th>
<th>Total Amount Feed Used (kg)</th>
<th>Variable Costs (USh.)</th>
<th>Total Variable Costs (USh.)</th>
<th>Total Sales (USh.)</th>
<th>Profit (USh.)</th>
<th>Gross Margin (%)</th>
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Table A above shows that above an FCR or 2.5 losses are made (profits are negative). In this case, the table shows that by reducing the FCR by a factor of 0.1, one can increase one’s profit margins by more than 10 % each time. For example a farmer who reduces the FCR from 2.3 to 2.2 one is able to increase ones earnings by about UShs. 169,000/= (i.e. USh. 569,250/= - USh. 400, 950/=) which is an increase of about 42 %. Reducing ones FCR from 2.1 to 2.0 result in an increase in profits margin by 23 %.
B: Change in fingerling Cost but FCR and feed cost are constant at 2.0 and USh. 1,000/= per kg respectively.

Table B: Effect of Reducing Fingerling Cost on Profit Margins

<table>
<thead>
<tr>
<th>Unit Cost of Fingerlings (USh.)</th>
<th>Variable Costsa (USh.)</th>
<th>Total Variable Costsa (USh.)</th>
<th>Total Salesb (USh.)</th>
<th>Profita (USh.)</th>
<th>Gross Margin (USh.)</th>
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Table B above shows that when the unit cost of fingerlings is reduced by USh. 10/=, profits increase by only 3 % to 4 %. For example, a reduction in fingerling cost to USh. 190/= from USh. 200/=, results in an increase in profits of only USh. 24,750/= which is a change of 3 % only.

Therefore, as much as possible, maintain your FCRs within an economic range because as has been illustrated above, a reduction in the FCR of just 0.1, makes big difference on profit margins. Bargain for a low price of fingerlings but a good farmer should be willing to pay a bit more for very high quality fingerlings. Remember, the other important factor in profitable production is having a high survival rate (preferably above 85%).

NOTE: For a viable enterprise, your seed costs should never exceed more than 30% of your variable costs. Seed costs exceeding 30% occur when stocking densities are too high and at the low management levels (see chapter 5.3.1) where feed is not used.

Footnotes:

a Amount Feed to Feed a kg of Fish
This is the amount of feed used up in feeding each kilogram of fish produced for the corresponding FCR stated in the table.

b Total Amount Feed Used (kg)
This is the total amount feed used to produce the estimated 1,683 kg of catfish harvested and sold at the specified FCR as explained in the assumptions above.

c Variable Costs (USh.)
The amount of money that was spent on feed and seed to produce the total amount of fish harvested as explained in the assumptions above.

d Total Variable Costs (USh.)
The total sum of the money spent on purchasing feed and seed.
**Appendices**

<table>
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<tr>
<th>Category</th>
<th>Description</th>
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<td>Total Sales (USh.)</td>
<td>The amount of money obtained from selling the fish produced before deducting the total variable costs (i.e. expenditure on feed and seed)</td>
</tr>
<tr>
<td>Profit (USh.)</td>
<td>The difference between the total sales and total variable costs. The profits are the farmers actual earnings</td>
</tr>
<tr>
<td>Gross Margin (%) (USh.)</td>
<td>This reflects the profit obtained as a percentage of the total sales, i.e.: ( \frac{\text{Profit}}{\text{Total Variable Cost}} \times 100 )</td>
</tr>
</tbody>
</table>
APPENDIX 7. How to fillet African Catfish

Requirements
- Fish skinner pliers
- Sharp filleting knife
- Clean smooth (non abrasive) filleting board in clean environment.
- Clean water
- Iced cooling box

Filleting process

Step 1
Get a catfish and keep it wet and clean.
Pith and bleed the catfish by positioning the pointy part of a big knife directly above its brain and spinal cord, then quickly pushing it down into the brain cavity. This is done as quickly and painless as possible.
Bleeding is done to improve flesh quality. When fish are not bled before hand, a lot of blood remains engorged in the flesh giving it a dark brown red colour. Shelf life is also reduced.

Step 2
Nick the skin around the head
Cut just through the skin in a ring around the base of the head; this is where to cut later to remove the head, but momentarily the head is left on to give a better grip on the fish.
This creates an edge from which to start skinning.
**Step 3**

Make two slits behind the head of the fish on both sides with a fillet knife. There is a muscle that attaches to the head and runs the length of the back. Make two incisions here just deep enough to pass through the skin. Using fingers pull up the skin so as to create a grip site for the skinner pliers. Use the skinner to peel back the skin and expose the muscle. The belly, which has white skin, should also be skinned.

![Fish being skinned](image1.png)

**Step 4**

Insert the knife into the top of the fish near the anal vent while the catfish is on its side. The knife is run gently along the backbone separating the meat from this bone. The muscles should just slip right off when the knife is run down the body if this step is done properly.

![Fish being filleted](image2.png)

**Step 5**

Slice away the fillet by bringing the broad side of the knife into the meat behind the gill. Press down until there is resistance from the bone. Run the knife along this path until it reaches the tail. Remove the fillet.

![Fish being filleted](image3.png)

**Step 6**

Flip the fish onto its other side and repeat steps four and five.
Step 7
Cut the meat flap (nugget) covering the belly. This will be a smaller piece about the size of a palm. If you angle the knife up under the ribs, you will get more meat.

Step 8
Keep the two fillets and the nugget cooled until ready for cooking or packaging. Remove the air from the bag before sealing. Thin plastic actually allows air to pass across it, so use thicker plastic or double-wrap to protect the fish when frozen. If the carcass and skin will be sold, keep them cool as well. Pig farmers often purchase fish skins.

You have the choice of throwing the meat into a plastic bag so it looks like a bloody mess, or positioning it nicely so it looks more appetizing. Some of these bags have the fillet nicely placed.
APPENDIX 8. How to Smoke Catfish using the Chokor Smoker

Steps for smoking catfish.

1. After harvesting the fish from the pond wash them thoroughly in clean water. Do not in any way put the fish directly on the ground.

2. Gut the fish by cut through the abdomen and remove all the intestines and other internal organs. Fish should be "split" as shown in the photo below.

3. Clean the fish thoroughly again by scrubbing with a brush.

4. Place the cleaned fish in a salt solution of 1 kg salt to every 5 litres for at least 3 hours. Spices can be added to the solutions if one so wishes to enhance the taste of the fish. The rates of salting is based on the volume of water used not the kilograms of fish to be smoked. When brining the fish, ensure that all the fish is fully immersed into the solution.

5. Spread the fish out on a rack to drip for at least an hour. Meanwhile light the fire in the smoking kiln. It is recommended that you use only freshly cut fruit trees to fuel the fire because other trees such as eucalyptus contain toxins which can be harmful to human health.

6. Place the fish on racks onto the kiln. During smoking the temperature of the fire has to be adjusted as highlighted in the table below in order to prevent burning the fish and obtain a good quality product.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Fire Condition</th>
<th>Duration (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 - 40</td>
<td>Just lit</td>
<td>0</td>
</tr>
<tr>
<td>40 - 60</td>
<td>Add wet wood to generate smoke</td>
<td>1</td>
</tr>
<tr>
<td>60</td>
<td>Cooking the fish</td>
<td>2 - 4</td>
</tr>
<tr>
<td>40</td>
<td>drying</td>
<td>4 - 6</td>
</tr>
<tr>
<td></td>
<td>Total Time</td>
<td>7 - 10</td>
</tr>
</tbody>
</table>
Note:

a. It is important to be able to control the temperature of the fire during the smoking process. This can be done by adjusting the amount of wood in the kiln and by adding fresh leaves.

b. During the process of smoking keep checking the fish to ensure it is not burning.

c. Fatty fish is difficult to smoke because the fat will start dripping and re-kindle the flame. Consequently the fish gets burnt. In addition, when the fat melts away, the fish shrinks a lot, and one is likely to make a loss at sale. Avoid smoking fatty fish.

7. When smoking catfish to add value one must know how much fresh whole fish does one require to get 1 kg of the smoked product. The weight of the smoked fish is likely to reduce by 40 to 50% of the live weight. Therefore, one kilogram of live fish after smoking shall be between 400 g to 500 g. The weight of smoked catfish fillets from a fish is likely to be 15 to 20% of the total live weight of the fish smoked.

8. Smoking Catfish as a Business.
The major operational costs one is likely to incur include labour, firewood, communication transport, spices/salt and packaging. In order to minimize the costs of smoking each fish then one must set a minimum number of trays on the kiln because with the same amount of firewood and labour, one can smoke from less than 10 kg up to 300 kg of fish at a time. The greater the quantity of fish smoked each run, the lower the cost of smoking shall be.

The photo below shows a smoking kiln newly constructed. Multiple shelves of the wood-framed grills can be layered on top of each other thus increasing the capacity of the smoker without increasing the need for wood. The lower shelves should be changed with the upper shelves during the smoking process. A cover is placed on the top-most layer to hold in the heat and smoke.
APPENDIX 9. Role of Uganda Wildlife Authority in Problem Animal and vermin Management (Mapesa, 2008)

UWA is a semi autonomous Government body charged with wildlife management both inside and outside protected areas. It was established in 1996 by an Act of Parliament through a merger of the former Uganda National Parks and Game Department. Currently it manages 10 National Parks, 12 Wildlife Reserves, 13 Wildlife Sanctuaries and 5 Community Wildlife Areas. It is also the regulatory body in managing wildlife that are resident outside Protected Areas (PAs).

UWA’s Mission Statement is:
‘To conserve, economically develop and sustainably manage wildlife and protected areas of Uganda in partnership with neighboring communities and other stakeholders for the benefit of the people of Uganda and the global community’.

UWA’s Vision is:
“To be a leading self sustaining wildlife conservation agency that transforms Uganda into one of the best tourist destinations in Africa.”

UGANDA’S WILDLIFE POLICY & LEGISLATION

The Government of Uganda Constitution (1995) under Article 237 (2) vests all wildlife in the Government. The overall government policy on natural resource conservation is enshrined in the Constitution, which provides that:
   (i) the state shall protect important natural resources such as land, water, wetlands, minerals, fauna and flora on behalf of the people of Uganda (Objective XIII), and
   (ii) the state shall create and develop parks and reserves to protect the biodiversity of Uganda. (Objective XXVII).

2. The Uganda Wildlife Act Cap. 200 of 2000
   (i) Co-ordinate the implementation of Government policies in the field of wildlife management,
   (ii) Establish policies and procedures for the sustainable utilization of wildlife by and for the benefit of the communities living in proximity to wildlife,
   (iii) Consider reports from district wildlife committees/units and make necessary comments and decisions.
   (iv) Develop and recommend policies on wildlife management to Government,
   (v) Monitor and control problem animals and provide technical advice on the control of vermin.

3. The Uganda Wildlife Policy (1999):
   (i) Build the capacity of farmers and district authorities to manage problem animals
   (ii) Develop and disseminate information and guidelines on problem animal control.
   (iii) Identify those species of wildlife that should be classified as vermin on a district by district basis.
   (iv) Advise districts as to the best methods of utilising and profiting from problem animals and vermin.
(v) Ensure that those most affected by problem animals are the main beneficiaries of revenue earned from their control.
(vi) Provide districts with awareness, technical assistance and capacity to monitor and conduct problem animal and vermin control activities.

4. **The Local Governments Act (1997).**
Part 4 of the second Schedule of the Local Governments Act (1997), the local Governments are mandated to control vermin in consultation with the ministry responsible for Tourism and Wildlife and any other relevant Ministry.

5. **The Land Act of 1998:**
   (i) Provides for Government (national or local) to acquire land for purpose of wildlife management.
   (ii) Occupier of land to manage and utilize the land in an environmentally sound manner, and in accordance with provisions of the other laws (Environment, Forest, Wildlife, Mineral, etc).

   Led to establishment of Problem animal control unit (PACU) and emphasize developing capacity of its staff and local government.

**CATEGORIES OF ANIMALS**
(i) Dangerous animals - section 58 of the Uganda Wildlife Act (Cap 200) 2000, animals gazetted as dangerous animals include Hyena, Lion, Leopard, Hippopotamus, Elephant, Rhinoceros, Crocodile, Gorilla or any other animal BOT by notice of Gazettee determines to be dangerous animal
(ii) Vermin-this means a wild animal that destroys crops/ and attack livestock and is declared to be vermin (section 57 of the Uganda Wildlife Act (Cap 200, 2000) In Uganda only three animals are vermin Olive baboon, Vervet monkey and Bush pig. The vermin becomes a vermin outside the protected areas.
(iii) Problem animals- includes any animal, which poses danger to human life or property.
(iv) Protected animals (fully and partially protected animals) Section 27(4).
(v) Fully protected animals are not subjected to wildlife use right (WUR).
(vi) Partially protected animals are utilised only subject to a grant of WUR.

**UWA’S ROLE IN PROBLEM ANIMALS/VERMIN MANAGEMENT**
(i) To put in place capacity to handle problem animals and monitor vermin control programmes.
(ii) Promote wildlife community friendly policies (e.g. grant wildlife use rights to local communities)
(iii) Conduct education and awareness programmes and information dissemination at all levels
(iv) Research on problem animal control methods
(v) Carry out monitoring and evaluation of problem animal control programmes
(vi) Support initiation of problem animal interventions (elephant trenches, live fencing)
(vii) Develop and recommend policies on wildlife management to Government
(viii) Co-ordinate the implementation of Government policies in the field of wildlife management

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Appendices
(ix) Establish policies and procedures for the sustainable utilization of wildlife by and for the benefit of the communities living in proximity to wildlife.

**UWA’S CURRENT INTERVENTIONS**

(i) Problem Animal Control (PAC) Strategy whose overall goal is to minimize losses and damage to human life and property caused by problem animals.

(ii) UWA has put in place capacity (PAC unit) to handle problem animals.

(iii) Support initiation of problem animal interventions (elephant trenches, live fencing, trapping, use of chili, Direct scare, Bomas, planting unpalatable crops and killing of animal).

(iv) Benefit sharing schemes. The scheme is a result of the implementation of the Uganda Wildlife Act that provides for 20% of all entry fee collections to flow directly to the relevant community neighbouring a protected area.

(v) Conducts education and awareness programs and information dissemination at all levels.

(vi) Promotes wildlife community friendly policies (e.g. grant wildlife use rights to local communities).

(vii) Provides technical assistance (training) to local governments to assist them carry out their roles (training of community vermin guards).

(viii) Researches on problem animal control methods.

(ix) Carries out monitoring and evaluation of problem animal control programmes.
## APPENDIX 10. Template Pond Production Plan

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. POND PROFILE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pond Area (m²)</td>
<td>Measure only the ponds <em>water surface area</em> when pond is full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Pond Water Depth (m)</td>
<td>measure water depth at about three intervals from inlet to outlet then get the average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pond Volume (m³)</td>
<td>[ h\frac{(A1 + A2) + (A1 \times A2)}{3} ] Where, ( A1 ) = area at water surface, ( A2 ) = area of pond bottom, ( h ) = average water depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. WATER REQUIREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected water demand (m³/cycle)</td>
<td>= pond volume \times 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflow Quality (ppm) (alk/hrd)</td>
<td>record your water quality parameters for alkalinity and hardness if available</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. STOCKING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected maximum <em>standing crop</em>, based upon your ponds <em>Carrying Capacity</em> (kg)</td>
<td>You should harvest before carrying capacity is reached, say when at 18 T/ha if carrying capacity is 20T/ha for the species and kind of fish being stocked (see feed chart)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targeted Market Size of Fish or Desired Size at Harvest</td>
<td>Record your targeted average size of fish at harvest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fish to be Stocked</td>
<td>= Critical <em>Standing crop</em> (kg) \times 10% Targeted Size at Harvest (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stocking Density (No. Fish/m²)</td>
<td>= \frac{Number of Fish Stocked}{Total Pond Water Area (m²)}</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4. GENERAL POND MANAGEMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated pond lime requirement (kg)</td>
<td>Varies depending on the pond soil pH. New ponds often require liming.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Variability in fertiliser requirements:

| Estimated fertiliser requirement (kg) | Varies depending on pond conditions. Earthen nursery ponds and tilapia grow-out pond perform best in green water even when artificial feed is used. In catfish grow-out monoculture fed commercial pellets, fertilisation is not necessary if fish are 15 cm long and above. |

5. FEED REQUIREMENTS

<table>
<thead>
<tr>
<th>Type of feed to feed</th>
<th>This depends on the size of the fish. Use the feed chart as a guide.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total amount of feed required during the cycle (kg)</td>
<td>For grow-out ponds on commercial pellets, base it on the maximum acceptable FCR = 2. Therefore, multiply your expected final pond biomass X 2</td>
</tr>
</tbody>
</table>

6. EXPECTED DURATION OF PRODUCTION CYCLE

<table>
<thead>
<tr>
<th>Expected Duration of Production in weeks</th>
<th>Use your feeding chart as a guide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= Weeks (Age) at Targeted harvest</td>
</tr>
<tr>
<td>Production days</td>
<td>Size - Weeks (Age) at Stocking</td>
</tr>
</tbody>
</table>

7. LABOUR REQUIREMENTS

| Labour for pond preparation and stocking | This can be difficult to work out for just one pond; it is mostly based upon all ponds for the farm |
| Daily labour for feeding, checking screens, inlet/outlet pipes, etc. | It is recommended that grow-out ponds are sampled once a month |
| Extra labour during sampling and harvesting (as well as cost of hiring associated equipment) | Also based upon the entire farm |

8. MARKETING REQUIREMENTS

| Transport | |
| Communication | Entire-farm based, not just one pond |
APPENDIX 11. Guidelines for Selecting a Technical Advisor

A: On Production
The person should have been directly involved in the production of at least 20 tons of fish in a year and have demonstrated ability to:
1. Make feeding schedules based on fish growth, size and feed type.
2. Holding and transport of live fish.
3. Keep and records and control inventory of fish.
5. Measure water quality parameters of importance and apply mitigation measures.
6. Supervise at least 5 workers on a commercial fish farm in harvesting, handling, weighing, sampling, feeding, fertilizing and water management.
7. Assess fish health and apply treatments as prescribed.

Demonstrated familiarity with water permit, Environmental Impact Assessment (EIA) and aquaculture permit requirements.

B: Pond Construction
The person should have been directly involved in the planning, supervision and construction/renovation of more than 20 ponds.

He or she should be in position to demonstrate ability to:
1. Plan water channels, inlets and outlets using rational design criteria.
2. Move soil efficiently with hand labour and machine.
3. Site new ponds and stake out dimensions for particular function and site topography.
4. Demarcate pond dykes and construct with proper compaction, elevations and slopes.
5. Design and plan work on paper. Estimate construction costs.
6. Assess soil quality for construction.
7. Measure water flow rates and volumes as well as apply pond construction and design.
8. Install drain pipes with ant-seep collars.
9. Plan and construct harvest basins inside and outside the pond.
10. Set out work tasks for unskilled workers.
11. Understand pipe installation and nomenclature used in PVC and HDPE plumbing works.
13. Be able to work with surveying levels and different, simple means of measuring elevation differences.

Demonstrated familiarity with water permit, Environmental Impact Assessment (EIA) and aquaculture permit requirements.

For the above specializations, the competent technical advisor must have the ability and training to know when more specialized advice is needed and where to source it. Diplomas, degrees and certificates that indicate training in the above areas are helpful but cannot replace the experience required.
APPENDIX 12.  Template Pond Record Management Sheet

<table>
<thead>
<tr>
<th>Pond:</th>
<th>Size: ___________________________</th>
<th>Function:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Stock</td>
<td>Treat</td>
</tr>
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</tbody>
</table>
APPENDIX 13. Template Daily Feed Record Sheet

FEED SHEET: week of

<table>
<thead>
<tr>
<th>Pond</th>
<th>Type feed</th>
<th>Amt to feed</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thur</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
<th>Tot kgs</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**Feeding Response:** E - excellent  G - good  F - fair  P - poor
APPENDIX 14. Conditions for Approved Fingerling Vendors

The vendor (where vendor refers to hatchery, nursery or middle-man) must be in a position to:

1. Know the age of the fingerlings. Age should be estimated within a week of birth.
2. Know the source of the parent stock.
3. Have verified pond records.
4. Have holding facilities available for keeping fingerlings for sale without feed for 48 hours in water with at least 4 mg/l of oxygen.
5. Have graded fingerlings of ages within 1 month of each other in a lot.
6. Give prophylactic dips of potassium permanganate, salt or formalin for each lot sold out.
7. Sale sizes not smaller than those recommended for stocking grow-out ponds as fingerlings, viz:
   a. Fingerling size for tilapia: 5g or more (hold 32)
   b. Fingerling size for catfish: 10 cm about 5g + (hold 40)
8. Any fish smaller than the recommended fingerling size should be sold as fry, priced accordingly, and NOT be sold to stock production ponds- they should go to nursery ponds first.
9. Quarterly reporting on sales and inventory.
10. It is highly recommended that at least one person at the hatchery is trained well enough to advise farmers on transport techniques and pond management; so, that the client is successful and returns to the same hatchery for more fingerlings.
11. Tags each transport bag with fish as recommended in Chapter 2....
APPENDIX 15. Legal Requirements for Commercial Aquaculture

Small holder and medium scale farmers only a couple of ponds raising local species of fish unless otherwise required need not apply.

1. Aquaculture

<table>
<thead>
<tr>
<th>Do I Intend to:</th>
<th>Permits/Certificates Required</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Semi-intensive(^1) or intensive(^2) grow-out operations</td>
<td>i) Aquaculture establishment certificate ii) Annual aquaculture farm data (due at end of each fiscal year)</td>
<td>i) EIA(^3) of project proposal</td>
</tr>
<tr>
<td>2. Fish Seed Production</td>
<td>i) Aquaculture establishment certificate ii) Fish seed production certificate</td>
<td>i) EIA(^3) of project proposal ii) Annual aquaculture farm data (due at end of each fiscal year)</td>
</tr>
<tr>
<td>3. Fish Breeding</td>
<td>i) Aquaculture establishment certificate ii) Fish seed production certificate</td>
<td>i) EIA(^3) of project proposal ii) Annual aquaculture farm data (due at end of each fiscal year)</td>
</tr>
<tr>
<td>4. Commercial Bait production</td>
<td>i) Aquaculture establishment certificate</td>
<td>i) EIA(^3) of project proposal ii) Annual aquaculture farm data (due at end of each fiscal year)</td>
</tr>
<tr>
<td>5. Ornamental Fish Farming</td>
<td>i) Aquaculture establishment certificate</td>
<td>i) EIA(^3) of project proposal ii) Annual aquaculture farm data (due at end of each fiscal year)</td>
</tr>
<tr>
<td>6. Marketing of Farmed Fish (transfer within Uganda)</td>
<td>i) Fish transfer permit</td>
<td></td>
</tr>
<tr>
<td>7. Export of Farmed Fish</td>
<td>i) Fish import/export permit</td>
<td></td>
</tr>
<tr>
<td>8. Genetic Material for Aquaculture</td>
<td>UN CST certificate</td>
<td>National Bio-safety guidelines followed</td>
</tr>
</tbody>
</table>
### 2. Water Use

<table>
<thead>
<tr>
<th>Do I Intend to:</th>
<th>Permits/Certificates Required</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| 1. Drill a borehole on my land to supply water to my fish farm | i) Drilling permit  
ii) Construction permit | i) register works and use of water with the Directorate of Water Development (DWD)  
ii) renewal of permit after the stipulated number of years |
| 2. Use a motorised pump to pump the water from the borehole either temporarily or permanently | i) Ground water permit | i) register works and use of water with the Directorate of Water Development (DWD)  
ii) renewal of permit after the stipulated number of years |
| 3. Impound a waterway\(^4\) to extract 270 litres of water per minute or more in a 24 hour period | i) Surface water permit  
ii) Construction permit | i) register works and use of water with the Directorate of Water Development (DWD)  
ii) renewal of permit after the stipulated number of years |
| 4. Use a motorised pump to pump water either temporarily or permanently from a waterway\(^4\) | i) Surface water permit | i) register works and use of water with the Directorate of Water Development (DWD)  
ii) renewal of permit after the stipulated number of years |
| 5. Discharge large amounts of effluent from the farm | i) Waste Discharge permit | i) register works and use of water with the Directorate of Water Development (DWD) |

### 3. Environmental Issues

<table>
<thead>
<tr>
<th>Do I Intend to:</th>
<th>Permits/Certificates Required</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| 1. Establish a large-scale\(^5\) commercial aquaculture | i) Certificate of Approval of Environment Impact Assessment | i) Project brief\(^5\) (10 copies submitted to NEMA)  
ii) Environment impact study\(^6\)  
iii) Environment impact statement\(^7\) |
Definitions

1. Semi-intensive
   The culture of fish using medium *stocking* densities which combines use of both natural and artificial feeds but does not include subsistence production systems.

2. Intensive
   The culture of fish using high *stocking* densities and complete diets.

3. EIA
   Environmental Impact Assessment

4. Waterway
   i) a river, creek, stream or water course
   ii) a natural channel in which water regularly flows, whether or not the flow is continuous
   iii) a channel formed wholly or partly by the alteration or relocation of a waterway as defined by (i) and (ii)
   iv) a lake, swamp or marsh

5. Project brief
   The first stage in the environmental impact assessment process – the project proposal

6. Environment impact study
   The study conducted to determine the possible environmental impacts of a proposed project and measures to mitigate their effects.

7. Environment impact statement
   The document describing the findings and recommendations of the environment impact study

8. UNCST
   Uganda National Council of Science and Technology

Contact Offices:

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   Fisheries Resources Department (FRD),
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3. Environmental Issues

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