

Review Article

AQUACULTURAL PRODUCTION AND MANAGEMENT IN NIGERIA

Comment [CM1]: Insert as "A REVIEW OR REVIEW OF AQUACULTURAL PRODUCTION AND MANAGEMENT IN NIGERIA"

ABSTRACT

Fish is an important source of food, income, jobs, and recreation for people around the world and it is a very important source of animal protein for both man and livestock in developed and developing Countries. In Nigeria, the current demand for fish is about four times the level of local production from all sources. Humans consume approximately 80 percent of the catch as food. The remaining 20 percent goes into the manufacturing of products such as fish oil, fertilizers, and animal food. Fish farming named aquaculture is an integral part of agriculture which was found to have the capacity to increase the country's GDP and can solve the unemployment problem for our teeming youths if adequately managed. Therefore, this paper revealed the status of Aquacultural production in Nigeria, hindrances to Aquacultural development in the country, different fish species that can adequately thrive in Nigerian pond and its preparation and finally showed some first-rate management practices that can boost aquacultural production in Nigeria.

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KEYWORDS: Aquaculture, Development, Management, Production, Stocking

INTRODUCTION

The demand for fish in Nigeria mostly outstrips the local production. Nigeria is the largest fish consumer in Africa and among the largest fish consumers in the world with over 1.5 millions tons of fish consumed annually. Yet, Nigeria imports over 900,000 metric tons of fish while its domestic catch is estimated at 450,000 metric tons/year (Ozigbo *et al.*, 2013). The statistic available indicates that the growth in fish production is due to increased activities of Aquaculture and the need for aquaculture arose from the decrease in supply from ocean fisheries as a result of over-fishing, habit destruction and pollutions (Adedeji and Okocha, 2011). Aquaculture is farming of aquatic organisms in fresh, brackish or salt water. A wide variety of aquatic organisms are produced through aquaculture. These include: fishes, crustaceans, molluscs, algae, and aquatic plants. Unlike capture fisheries, aquaculture requires deliberate human intervention in the organisms' productivity which results in yields that exceed those from the natural environment alone. Such interventions are stocking water with seed (fingerlings), fertilizing the water, feeding the organisms, and maintaining water quality (Green, 2008). Objectives of aquaculture are as follows: production of protein rich, nutritive, palatable and easily digestible human food benefiting the whole society through plentiful food supplies at low or reasonable cost; providing new species and strengthening

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37 stocks of existing fish in natural and man-made water-bodies through artificial recruitment
38 and transplantation; production of sport-fish and support to recreational fishing; production of
39 bait-fish for commercial and sport fishery; production of ornamental fish for aesthetic appeal,
40 recycling of organic waste of human and livestock origin, land and aquatic resource
41 utilization: this constitutes the macro-economic point of view benefiting the whole society. It
42 involves (a) maximum resource allocation to aquaculture and its optimal utilization; (b)
43 increasing standard of living by maximising profitability; and (c) creation of production
44 surplus for export (earning foreign exchange especially important to most developing
45 countries) (Jhingran, 2001).

46 STATUS OF AQUACULTURE IN NIGERIA

47 Aquaculture was developed more than 2,000 years ago in countries such as China, Rome, and
48 Egypt. Not long after, aquacultural practices in Europe, China, and Japan commonly involved
49 stocking wild-caught fingerlings — for example, carp fingerlings (juvenile fish) captured
50 from rivers — in ponds or other bodies of water for further growth (Green, 2008). The World
51 leading aquaculture producers today is the Asia and America. The U.S. aquaculture
52 production rose more than 400 percent between 1980 and 2000 (Jhingran, 2001). The
53 substantial increase in aquacultural production in countries like United States is as result of
54 aquacultural mechanization which has led to increased productivity, labour efficiency and
55 improved product quality. Unlike Asia, Africa has little aquaculture tradition and has been
56 affected by a number of external problems that have prevented proper management and
57 development despite the investment. A number of countries in sub-Saharan Africa are
58 characterized by low agricultural production, poor management of resources, economic
59 stagnation, persistent political instability, lack of technical knowhow, increasing
60 environmental damage, and severe poverty.

61 Although aquaculture activity in Nigeria started about 50 years ago (Olagunju *et al.*, 2007),
62 yet Nigeria has not been able to meet domestic production demand for the populace.
63 According to Ekunwe and Emokaro (2009) statistics indicate that Nigeria is the largest
64 African aquaculture producer, with production output of over 15,489 tonnes per annum, this
65 is closely followed by Egypt with output of about 5,645 tonnes. Only five other countries:
66 Zambia, Madagascar, Togo, Kenya and Sudan produce more than 1,000 tonnes each. This
67 result shows that Africa in general is far behind in aquacultural production. In Nigeria,
68 aquaculture development has been driven by social and economic objectives, such as
69 nutrition improvement in rural areas, generation of supplementary income, diversification of

Comment [CM8]: Change to "Italy" as Rome is not a country

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Comment [CM11]: Insert as "United States of America (U.S.A.)"

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70 income activities, and the creation of employment. This is especially true in rural
71 communities, where opportunities for economic activities are limited. Only in recent years
72 has aquaculture been viewed as an activity likely to meet national shortfalls in fish supplies,
73 thereby reducing fish imports. The fisheries sector accounts for about 2% of national G.D.P,
74 40% of the animal protein intake and a substantial proportion of employment, especially in
75 the rural areas; the sector is a principal source of livelihood for over three million people in
76 Nigeria (Adedeji and Okocha, 2011).

77 Nigeria has the natural resources (such as land, rivers, streams, reservoirs and lakes; and the
78 human resource) and potentials to compete with the world leading aquacultural countries.
79 First is the natural resource such as lands, rivers, streams, reservoirs and lakes. Second is the
80 human resource. Millions of Nigerian youths are ready and equally available to work any
81 time of the day. Of course, one can agree with me that Nigeria lacks no work force. In spite
82 of the great potentials of fish farming in Nigeria, the country Nigeria is still currently unable
83 to bridge the gap in the short fall between total domestic fish production and the total
84 domestic demand. What exactly is wrong with Nigeria?

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86 HINDERANCES OF AQUACULTURAL GROWTH AND DEVELOPMENT IN 87 NIGERIA

88 Nigeria as a nation is endowed with good natural resources which can enhance aquacultural
89 development to a greater extent, however, the reverse is the case. Many researchers are
90 asking questions. Is it leadership problem or lack of skills required for the production or lack
91 of awareness on the importance of aquaculture to national development? Of course,
92 aquaculture benefits are numerous; it creates jobs which settle the unemployment issue and it
93 is prolific and profitable, generate income for individuals, serves as recreation centers for
94 relaxation, can attract foreign exchange capable of increasing the country's GDP and so on.
95 Let us look at some researchers' view on the militants of aquacultural development in our
96 country:

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97 Adewumi & Olaleye (2011) found out that a number of problems confront the production of
98 catfish; being a major specie in Nigeria. Prominent among these are: poor management skills,
99 inadequate supply of good quality seed, lack of capital, high cost of feed, faulty data
100 collection, lack of environmental impact consideration and marketing of products. If the
101 associated problems of production, especially the twin issue of feed production and fingerling
102 supply are tackled, Nigeria will soon become a world exporter of catfish. According to Oota
103 cited in Oyinbo and Rekwot (2013), high cost of input, lack of credit to fish farmers at low

Comment [CM21]: Change to "species"

104 interest rate, lack of skilled manpower and an ineffective aquaculture extension service
105 system are attributes contributing to underdevelopment of aquaculture in the country. While
106 George *et al* (2010) stated that the major problem hindering the promotion and development
107 of the aquaculture industry in Nigeria has been the scarcity of fish fingerlings and that the
108 major factors militating against the production of high quantity of fish seed are energy and
109 water quality related problems arising from skills gap in the industry.

110 FISH SPECIES GROWN IN NIGERIA

111 Fishes are diverse group of animals that live and breathe in water. All fishes are vertebrates
112 (animals with backbones) with gills for breathing. Most fish have fins for swimming, scales
113 for protection, and a streamlined body for moving easily through the water.
114 Fishes are generally streamlined with a pointed snout and pointed posterior and a broad
115 propulsive tail. Unlike the shape of a human body, a fish's body shape is ideal for speeding
116 through the water without creating excess resistance (Green, 2008). The major species
117 cultured in Nigeria include tilapias, catfish and carp. However, the African catfish species
118 (*Clarias gariepinus* or *lazera*) are the most resistant and widely accepted and highly valued
119 fish that could be cultivated in Nigeria. According to Adewumi & Olaleye (2011), it is major
120 specie reared in Nigeria.

121 *Clarias* spp. (*C. lazera* or *gariepinus*) popularly known as CatFish

- 122 • Its body has no scales
- 123 • Has omnivorous feeding habit
- 124 • It preys heavily on other species and even on its own fry and fingerlings.
- 125 • Usually it is not stocked alone but along with tilapia which provides food for it.
- 126 • It has relatively slow growth rate (when compared to with common Carp and
127 Heterotis)
- 128 • The flesh is very tasty and free from bones.

129 Other most common fish species that can be grown in Nigeria earthen ponds include:

130 *Tilapia* spp. (*T. guineensis* and *T. niloticus*)

- 131 • Its whole body is heavily covered with scales
- 132 • It has omnivorous feeding habit
- 133 • Very prolific. Hence it reproduces at a very rapid rate.
- 134 • Its flesh is very bony but the bones can be separated and removed especially when the
135 fish is big.

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Comment [CM25]: Italics

Comment [CM26]: Small letter

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Comment [CM28]: Italics and insert as (*O. guineensis*)

Comment [CM29]: Italics and insert as (*O. niloticus*)

- 136 • The flesh has a delicious taste.

137 **Cyprinus carpio (Carp)**

Comment [CM30]: Italics

- 138 • It **had** few large shiny scales
- 139 • It is sluggish and this makes it an easy prey for Clarias. Hence it is not advisable to
- 140 stock it together with Clarias in the same pond.
- 141 • Does not grow well without supplementary feeding.
- 142 • It grows at a fast rate when **led** well and can attain 2kg in 8-10 months
- 143 • It has genetic potential to grow to a very large size (up to 10kg).

Comment [CM31]: Change to "has"

Comment [CM32]: Change to "fed"

144

145 **FISH POND PREPARATION**

146 **A Fish Pond** is a controlled pond, artificial lake, or reservoir that is stocked with fish and is

147 used in aquaculture for fish farming, or is used for recreational fishing or for ornamental

148 purposes. Before a pond can be stocked **for a new fish, the excessive wastes, which**

149 accumulate in the pond during the previous farming, must be removed and the soil and water

150 conditioned or upon a newly constructed pond, the following preparations have to **take been**

151 into consideration: cleaning, liming, eradication of predators, fertilization, and aeration.

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Comment [CM34]: Insert as "be taken"

152 **Cleaning** – There are two methods of cleaning; the drying method and wet method. The

153 drying method occurs where the ponds can be completely dried like a concrete pond.

154 Whereas, the wet method takes place in ponds like earthen ponds in which the water in the

155 pond cannot be completely dried.

156 **Liming** – Once the pond is cleaned, it is then filled with water and left overnight before

157 flushing out to remove debris and elevate the pH. This process should be repeated until the

158 pH of the water remains above 7, and only then the lime is applied. The types of lime to be

159 used depend on the water pH. It is recommended that agricultural lime (CaCO_3) or dolomite

160 [$\text{CaMg}(\text{CO}_3)_2$] should be used in a pond with water pH near neutral and the hydrated lime

161 [$\text{Ca}(\text{OH})_2$] should be used in a pond with water pH below 5 (KAU, 2013). The amount of

162 lime to be used should be carefully calculated to avoid inducing an excessively high water

163 pH, which may increase ammonia toxicity and result in the mortality of the fish stocked.

164 When the pond is properly limed and filled with water, the average water pH should be

165 between 7.5 - 8.5 with daily fluctuation of less than 0.5.

166 **Eradication of Predators** – After liming, the pond should be **filled** to the maximum depth

167 through a screen with fine mesh to prevent the predators and competitors from entering the

168 pond. Some chemicals should be used to eradicate these animals in the pond before stocking.

Comment [CM35]: Insert as "filled with water"

169 Fish can be killed by the application of tea seed powder at the rate of 20-30 ppm. After the
170 application of tea seed, the pond should be left for 3 days before the post larvae can be
171 stocked. Hypochlorite, either calcium or sodium salt, is currently used at 15-20% (60% active
172 ingredient) to eliminate both vertebrates and invertebrates. The pond must be cleaned prior to
173 the application of hypochlorite since hypochlorite may react with the organic matters and
174 produces the toxic organochlorine compounds. Hypochlorite should be applied after the pond
175 is filled to the maximum height and left for 3 days to allow the hatching of planktonic
176 organisms. After the hypochlorite application, the pond should be aerated and the application
177 of lime and fertilizer should be conducted on Day 3, then **stock** on Day 7. During the first
178 month, water must not be added to the pond, unless the water quality is poor, to prevent the
179 introduction of competitors and predators.

Comment [CM36]: Insert as “stocked with fish”

180 **Fertilization** – The pond must be fertilized with either organic or inorganic fertilizer to
181 stimulate the plankton bloom in order to provide shade to the pond bottom and utilize the
182 nitrogenous and phosphate wastes within the pond. The shade will also prevent the growth of
183 harmful benthic algae. The sun dried chicken manure is the most common organic fertilizer
184 to be used in **the amount** of 200-300 kg/ha. The manure must be soaked in water for 24 hours
185 before it is spread over the surface of the water. Inorganic fertilizers, such as urea (46% N)
186 and compound fertilizers like, ammonium phosphate (16:20:0) or those with N:P:K
187 combination of (16:16:16) can be used at 20-30 kg./ha (KAU, 2013). The fertilizer must be
188 dissolved in water before it is spread over the water surface to avoid precipitation of the
189 fertilizer onto the pond bottom, which will enrich the soil and accelerate the growth of
190 benthic algae.

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191 **Aeration** – 0.5-1.0 ha pond would require, four aerators installed at the corners of the pond,
192 approximately 3-5 m from the bottom of the dike and positioned at an angle that will
193 encourage the maximum water flow within the pond. The type of aerator to be used depends
194 on the depth of the water. One horsepower paddle wheel aerators should be used in ponds of
195 less than 1.2 m water depth and the 2 HP (horsepower) paddle wheel aerators should be used
196 in ponds deeper than 1.2 m. The aerators should be switched-on 24 hrs before the post larvae
197 are stocked to allow enough time to create the current and clean up the feeding area (KAU,
198 2013).

199

200 **FISH FEED AND FEEDING**

201 **Fish feed** is a plant or animal material intended for consumption by fish, kept in aquacultural
202 systems. Fish feeds normally contain macronutrients, trace elements and vitamins necessary

203 to keep captive fish in good health. Depending on the type of the system in which the fish is
204 being reared (intensive, semi-intensive and extensive system). The fish can be fed by natural
205 and supplementary feeds or combination of both. Riche and Garling (2003) reported that fish
206 reared in intensive tank systems requires all nutrients in a complete pelleted diet since natural
207 food is limited and fish cannot forage freely for natural foods. Also, depending on the size,
208 there are different types of the formulated feed namely: hard pellet and floating pellet of
209 different sizes: 0.5mm, 0.8mm, 1mm, 2mm, 3mm, 4.5mm, 6mm, and even 10mm (1cm) for
210 larger fish. The hard pellets usually sink to the bottom of the aquacultural facilities while the
211 floating does not. The floating ability depends on the degree of fineness of the grounded food
212 components and mixing power of the machine.

213 **Feeding** is usually the largest operational cost of growing fish in aquaculture. The feed can
214 represent greater than 50% of the variable costs in growing fish. Labour and feeding
215 equipment are contributors to the total cost of feeding the aquacultural crop. Delivering the
216 feed to fish at the right time, in the correct form, and in the right amount is necessary for
217 optimal growth. The choice of feeding equipment depends on factors such as type and life
218 stage of fish, type and size of feed, size of the operation, available labor, and the type of
219 culture system. Therefore, a careful analysis of these factors is essential for successful and
220 profitable fish culture.

221 There are three groups of feeders and feeding methods—hand, automatic, and demand-used
222 to deliver formulated diets. The type of feeding system depends on the life stage of fish being
223 cultured, size of operation, type of diet, available resources, and personal preferences. This is
224 because larval and smaller fish require frequent feeding, they are often fed with automated
225 feeders that can be set to feed throughout the day at regular intervals. Smaller aquacultural
226 operations may have sufficient labor to feed all stocks by hand while in larger operations,
227 hand feeding becomes a problem unless larger, automated equipment is used. Whatever
228 method is used to facilitate feeding, the operator must periodically check for feeding
229 effectiveness by sampling and weighting fish, calculating feed-conversion ratios, and
230 adjusting the feeding rates (Summerfelt and Wade, 1997).

231 **Hand Feeding** – Manual or hand feeding can be used in all types of aquacultural systems -
232 cage, net, pond, flow-through, and recirculating and is often the method of choice for small
233 systems. Hand feeding can reduce capital expenditures for equipment, provided sufficient
234 labour is available to perform the feeding duties. There are other advantages to hand feeding;
235 the fish can be observed at each feeding for feeding behaviour to determine if they are
236 actively eating all of the food presented to them. Floating pellets make observations easier.

Comment [CM38]: Change to "labour"

Comment [CM39]: Change to "labour"

237 Fish can only be routinely fed to satiation by hand feeding. Observing the fish during feeding
238 can also be critical in the early determination of disease or parasite problems.

239 **Demand Feeders** – The cultured fish can be allowed to determine for themselves how much
240 feed is made available when demand feeders are used. Demand feeders can be used to make
241 food continuously available and allows for the fish to feed to satiation. Typically, fish fed
242 with demand feeders consume amounts of feed similar to what they would eat. The demand
243 feeders must, however, be readily accessible to the fish, and sufficient numbers of feeders
244 must be strategically located around larger systems. Fish are trained to hit the trigger of a
245 demand feeder when hungry and then become self-feeding. Some demand systems use a
246 touch-sensitive trigger to activate some kind of mechanical delivery system. Other
247 modifications of the demand feeder use an in-water feed tray that activates feed release as
248 feed is eaten from the tray. Usually, all of the demand feeders are adjustable for food size and
249 amount released per trigger activation. It takes classically about 7 to 10 days for rainbow
250 trout to train and feeding to stabilize on demand feeders (Summerfelt and Wade, 1997).
251 Demand feeders make feed available 24 hours per day and result in less size variability in the
252 harvested fish. Trout fed with demand feeders can have up to 10% better feed conversion
253 than in hand-fed systems. Other advantages from demand feeders are lower production costs
254 from reduced labour requirements and increased feeding efficiency. Trout on demand feeders
255 showed fewer disease problems and fewer problems with dissolved oxygen sags and
256 ammonia spikes from heavy feedings.

257 **Automatic Feeders** – An automatic feeder is basically a mechanism that delivers a
258 prescribed amount of feed to the fish at desired time intervals. The major advantage of
259 automatic feeders is the reduction in labour equipments necessitated by hand feeding,
260 especially in larger operations. Automated feeders have been adapted from other livestock
261 operations to provide cost-effective means to meet the array of needs for aquaculture. One
262 key feature of automatic feeders is some kind of programmable device that allows the
263 operator to vary the frequency and amount of feeding. This may be a combination of
264 electrical and mechanical components that broadcast feed into the culture system. Some
265 systems use electrical timers to determine the frequency, which are available from most
266 aquacultural equipment suppliers. Ideally, the settings for frequency will allow enough
267 flexibility to meet the needs of the fish. For smaller fish, the frequency may need to be
268 several times per hour, and for larger fish the frequency could be hourly or longer (Goddard,
269 1996). Automatic feeders use some kind of mechanical or pneumatic delivery system to
270 present feed to the fish.

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271 **PRODUCTION MANAGEMENT**

272 The purpose of fish management is to provide good fishing that will lead to increased yield.
273 Pond owners must decide what they want from their pond and tailor their management to
274 meet their goal(s). Fish business in generally is prolific if proper handling and management
275 precautions are adapted. The major management practices necessary for effective production
276 are as follows; fish stocking density, feeding, water quality control, diseases control and
277 record keeping. In case of feeding, please refer to the article above.

Comment [CM41]: Change to "fisheries"

Comment [CM42]: Change to "is"

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Comment [CM44]: Change to "Feeding has already been discussed above or In the case of feeding, it has already been discussed in this article"

278 **Fish Stocking Density** – Stocking marks the beginning of production cycle. Stocking density
279 of any aquacultural pond has to be first and foremost considered in management principles.
280 This is because if a pond exceeds its carrying capacity, fish stress is bound to occur which
281 can eventually lead to fish death. The process of stocking referred to here, starts with the
282 collection of fingerlings from the hatchery, transporting them to the farm and, finally, putting
283 them into the pond. Poor stocking procedures, are among the major causes of low survival in
284 grow-out ponds Nelly *et al* (2009). They result in disease, reduced growth and mortality.
285 Also, quality fingerlings are another important factor to note while stocking. Poor quality
286 stock will give poor production performance regardless of other factors. The most important
287 practical criteria for assessing the quality of fingerlings are source, physical appearance and
288 how they swim. A Pond's carrying capacity is influenced by the following: the size of fish in
289 the pond (because this influences the feeding rate); the species of fish being raised because
290 fish like *Clarias spp* become air breathers and do not need to rely on dissolved oxygen in the
291 pond, therefore the carrying capacity is higher for *Clarias spp* compared to *Tilapia*; the
292 amount and type of feed or fertilizer added to the pond and the water volume and quality.
293 The equation below illustrates how the number of fish to be stocked in a pond can be
294 estimated based on the pond's carrying capacity by Nelly *et al* (2009).

Comment [CM45]: Insert "s"

Comment [CM46]: Change to "mortalities"

Comment [CM47]: Insert "A"

Comment [CM48]: Insert "d"

Comment [CM49]: Italics and insert "spp"

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295
$$\text{Number to stock} = \frac{\text{Estimated maximum carrying capacity of a pond (kg)}}{\text{Desired weight at harvest (kg)}} + 10\%$$

297
298 **EXAMPLE:** The size of pond to be stocked is 1,000 m². The size of fingerlings is 15 g and
299 the targeted size for harvest is 800g. The intended management regime is catfish monoculture
300 fed entirely on commercial nutritionally-complete pellets in static water ponds.

301 How many fish should be stocked?

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

304

$$\begin{aligned}
 &= \frac{(1,000 \text{ m}^2 \times 1.8 \text{ kg/m}^2)}{0.8 \text{ kg}} + 10\% \text{ of } \frac{(1,000 \text{ m}^2 \times 1.8 \text{ kg/m}^2)}{0.8 \text{ kg}} \\
 &= 2,250 + 225 \\
 &= \mathbf{2,475 \text{ fingerlings should be stocked}}
 \end{aligned}$$

Water Quality – Water quality is the second aspect to consider in aquacultural management.

The failure and success of the production lies on this key factor. Poor water quality at high level does not spare the life of the fish for a minute. Therefore, this has to be checked regularly as prescribed below. The basic water quality parameters of source water that are important in maintaining fish health include: dissolved oxygen (>4.0 mg/l), salinity (15-32 ppt), temperature (26-30°C), pH (7.0-8.5), nitrogen compounds [ammonia (< 0.15 mg/l), nitrate and nitrite (< 4.5 mg/l)], BOD [5day (50/30mg/l)], hydrogen sulphide (< 0.1 mg/l) and pesticides (Andrew, 2007).

These should all be checked at different times: oxygen and temperature are measured at least twice daily to determine the influence of photosynthesis on concentrations. Salinity and pH are measured daily, and nitrate, ammonia and nitrite can be measured 2-3 times per week. Pesticides (those known to be used in watershed) should be tested periodically and at different rainfall levels to determine the effect of runoff on concentrations. Also check during periods of high rainfall as increased water flow that will influences water quality and may increase pesticides, sediment, and organic loading. Measure other parameters several times over a month period to know ranges. Know what pesticides are being used in the watershed and when, understand their toxicity, and test water periodically for those compounds.

Fish Diseases – High productivity in aquacultural production only transpire when fish are healthy and free from diseases. Fish disease management is aimed at preventing the onset of disease and measures to reduce losses from disease when it occurs. Let us see some common fish diseases, their causes and management control:

Vibriosis is a bacterial disease causing significant losses of fish in marine fish farms. Vibriosis accounts for an estimated two-thirds of disease reported in grouper species. Vibriosis results in severe skin, muscle, fin, eye and internal organ damage of fish. Stressors that trigger vibriosis outbreaks include high water temperatures, high stocking densities, poor handling of fish, and an organically polluted culture environment. Antibacterial medication, reducing stocking densities, careful handling of fish, improving the culture environment through the use of clean pelleted feeds, stocking of fish in cooler season of the year and vaccination are important control measures (Roger *et al.*, 2011).

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339 **Streptococcus** is a disease of freshwater pond fish cultures, particularly **Streptococcus**
340 **agalactiae** of tilapia (**Oreochromis spp.**). Clinical signs include cloudy eyes, exophthalmos and
341 focal, ulcerative skin lesions along the caudal peduncle area. Control of streptococcosis relies
342 on the administration of an antibiotic to which the isolate is sensitive together with control of
343 any associated ectoparasites and appropriate risk reducing husbandry measures. Preventative
344 measures are dependent on an effective vaccine against the pathogenic strains of
345 **Streptococcus** present in the fish environment or to which the susceptible fish stocks are
346 likely to encounter (Roger *et al.*, 2011). Others diseases include Benediniasis, viral
347 hemorrhagic septicemia, **Myxobolus cerebralis** (whirling disease), **Ichthyophthirius**
348 **multifiliis**, **Epinephelus lanceolatus**, Viral Encephalopathy and Retinopathy (VER) Disease.

Comment [CM60]: Italics

Comment [CM61]: Italics

349 Record Keeping

350 Keep thorough records from the onset of stocking to the harvesting period — they are
351 valuable in health management. Keep accurate records of numbers and sizes of fingerlings,
352 time, type and quantity of the feed fed, periods of water changed, time of aeration, date of
353 treatment and vaccination, etc. These records will help you evaluate the status of your fish
354 populations and provide you with proper guide to next farming.

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355 CONCLUSION

356 Standards for development of aquaculture are not beyond the country's potentials. As can be
357 deduced from the researchers' views on factors that hinder the development of aquaculture in
358 the country, the problem is simply tagged to be lack of management skills, government
359 support and the scarcity of the fingerlings. Nevertheless, proper pond design, good stocking
360 and water quality management are essential to successful and quality fish production.
361 Consequently, maintaining a good culture environment through use of proper management
362 practices will reduce the risk of disease and increase production, fish quality, and
363 marketability. Therefore, it is essential to implement and follow good aquaculture
364 management practices to ensure quality and quantity yield. Upon production for national
365 growth and development, our governments are still sleeping, busy pursuing crude oil sector
366 not knowing that what a rapid population growing company like Nigeria need is a diversified
367 economy. Nobody is talking about agricultural sector, a key, unlocking the padlock of food
368 insecurity let alone its subsector, aquaculture. We cannot continue to rely on importation of
369 every consumer goods, even the ones the country can comfortably and successfully produce.
370 Sooner than later, Nigeria will be a dumping zone for African countries. Statistics has that
371 Nigeria spends N100 billion on fish importation annually. Undoubtedly, if this kind of

Comment [CM64]: Change to "considered"

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Comment [CM66]: Recast as "The agricultural sector is a key to unlocking the padlock of food insecurity, let alone aquaculture subsector."

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Comment [CM68]: Delete and insert "indicate"

amount would be used in the river-line zones of the country for establishment of aquaculture production, definitely no one would remember the ugly story in the next few decades and unemployment rate will be reduced.

Comment [CM69]: Please clarify and qualify the statement.

REFERENCES

- Adedeji O.B. and Okocha R.C. (2011). "Constraint to Aquaculture Development in Nigeria and Way Forward" Veterinary Public Health and Preventive Medicine University of Ibadan, Nigeria.
- Adewumi, A.A & Olaleye, V.F. (2011). Catfish culture in Nigeria: Progress, Prospects and Problems. African Journal of Agricultural Research, 6(6): 1281-1285
- Andrew Lazur (2007). "Grow-out Pond and Water Quality Management". JIFSAN (Joint Institute for Safety and applied Nutrition) Good Aquacultural Practices Program, University of Maryland.
- Ekunwe, P.A and C.O. Emokaro (2009). Technical Efficiency of Catfish Farmers in Kaduna, Nigeria Journal of Applied Sciences Research., 5(7): 802-805.
- George, F.O.A., Olaoye, O. J., Akande, O. P. & Oghobase, R. R.(2010). Determinants of Aquaculture Fish Seed Production and Development in Ogun State, Nigeria. Journal of Sustainable Development in Africa, 12(8): 22 – 34.
- Goddard, S. 1996. Feed Management in Intensive Aquaculture. Chapman and Hall, New York.
- Green, Bartholomew W. (2008)"Aquaculture." Microsoft® Encarta® 2009.
- Jhingran, V.G., Introduction to aquaculture (2001). United Nations Development Programme, Food and Agriculture Organization of the United Nations, Nigerian Institute for Oceanography and Marine Research.
- KAU (2013). "Pond Preparation" Infotech Portal Centre for E –Learning Kerala Agricultural University.
- Nelly A. Isyagi, Karen L. Veverica, Rashid Asimwe, and William H. Daniels (2009). "Manual for the Commercial Pond Production of the African Catfish in Uganda" Department of Fisheries and Allied Aquacultures; Auburn University, Alabama, USA.
- Olagunju F.I, Adesiyun I.O, Ezekiel A.A (2007). Economic viability of cat fish production in Oyo state, Nigeria. J. Hum. Ecol. 21(2):121 - 124.

Comment [CM70]: What does this stand for?

404 Oyinbo Oyakhilomen and Rekwot Grace Zibah (2013) “Fishery Production and Economic
405 Growth in Nigeria: Pathway for Sustainable Economic Development” Department of
406 Agricultural Economics and Rural Sociology, Ahmadu Bello University, Nigeria –
407 Journal of Sustainable Development in Africa. Vol. 5. No.2, 2013.

408 Ozigbo Emmanuel, Anyadike Chinenye, Forolunsho Gbadebo, Okechuckwu Richardson and
409 Kolawole Peter (2013). “Development of an Automatic Fish Feeder” International
410 Institute of Tropical Agriculture Postharvest Unit, Ibadan – African Journal of Root
411 and Tuber Crop. Vol.10 No.1 Page 27-32.

412 Riche, M., D. Garling, 2003. Feeding Tilapia in intensive recirculatory systems. North central
413 Regional Aquaculture Centre and United State Department of Agriculture USDA. pp:
414 1-4.

415 Roger Chong, Barry Bousfield and Richard Brown (2011). “Fish Disease Management”
416 Veterinary Bulletin - Agriculture, Fisheries and Conservation Department Newsletter,
417 Hong Kong. Volume No. 1 Issue No. 8. December, 2011.

418 Summerfelt, S. T. and E.M. Wade. 1997. Recent advances in water treatment processes to
419 intensity fish production in large recirculating systems. in M. Timmons (ed) successes
420 and failure in commercial Aquaculture (Conference Proceedings).

Comment [CM71]: Be consistent on references
“(2003)”

Comment [CM72]: Be consistent on references
“(1997)”