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Article

AQUACULTURE TECHNOLOGY: FISH POND DESIGN, CONSTRUCTION, AND MANAGEMENT IN BORNO STATE, NIGERIA

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ABSTRACT

Objectives: The aim of the study was to assessment of aquaculture technology in fish pond design, construction, and management for technological advancement and sustainable development of the sub-sector in Maiduguri, Borno State, Nigeria.

Methods: Data for the study were obtained through primary and secondary sources through the survey method with the used of checklist. Self-reporting through administrative sources (off-site) contact method was also applied. Qualitative and descriptive techniques of data analysis were used and results on aquaculture technology in the study area were presented.

Results: The result shows that fish farmers are in a better position in the technological activities of pond design, construction, and management but wholly not conversant with some of the aspects such as identification of types of soil for positioning of pond, determination of technical implication of shape of the land on site selection for fish pond construction, planning for the layout of fish farm and pond before the commencement of construction work, and fertilization and liming of the fish pond.

Conclusion: The development of fish pond is carried out with the aid of the learned and experience fish farmers due to the technological inadequacy in the study area. Recommendations are made for rapid transformation of the sub-sector for the attainment of sustainable technological development in the study area.

Keywords: Aquaculture, Construction, Design, Fish pond, Management, Technology.

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INTRODUCTION

Technological developments keep improving efficiency by reducing costs and saving energy. Examples include innovations in propulsion system, improvements in vessels hull design, reduced use of wooden vessels, and the use of larger vessels. Other technological innovations focus on increasing fishing efficiency and reducing environmental or ecological impacts. Improvement in fishing technology and operations to address resource sustainability includes innovations in high-resolution underwater cameras to monitor fish behavior, etc. Despite the technological improvements, overcapacity is negatively affecting the profitability of many fishing fleets. Techno-economic performance assessment of the world's main fishing fleets shows aging fleets as lower levels of vessels profitability lead to reduced investment [1].

Regarding market access, better opportunities for small-scale fishers and their products do exist. Approaches and tools are available to overcome issues, such as compliance with food safety regulations, lack of appropriate technology in the area of improved processing, information and communication technology, and low levels of organizational capacity to ensure small-scale fisheries actors benefit fully from access to lucrative markets. Regulatory framework and an enabling environment that recognize and protect small-scale fishers' rights to access fisheries resources and build their capacity to access the market require that appropriate legal, regulatory, and policy frameworks, specific initiatives to support small-scale fisheries, and related institutional mechanism that allow for the participation of small-scale fisheries organizations in management and related processes shall be properly placed [2].

Aquaculture is one of the nine commodity compacts with proven technologies that have the potential to increase yields and benefits for upscaling in 12 countries in Africa: Benin, Burundi, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo, and Zambia. The agricultural compacts; technology for African Agricultural Transformation is a framework developed by the African development bank as part of its efforts for agricultural transformation on the continent. It aims to enhance the use of proven agricultural technologies among stakeholders to foster the changes needed through farm-level productivity and value chain development [3].

Nigeria is the largest producer of world's largest producer of African catfish (*Clarias gariepinus*). However, the annual consumption of fish in Nigeria is 3.6 million metric tons and Nigeria produces only about 1.23 million metric tons, leaving a deficit of 2.5 million metric tons that must be imported. The production from natural stock (wild aquatic environments) has drastically fallen due to overfishing and global warming. Therefore, catches from wild sources cannot keep up with the demand presented by the growing human population. These shortages have jeopardized the current protein intake (45.5 g/day) among Nigerians which is below the food and agricultural organizations of the United Nation's 53.8 g/day protein intake recommendation [4].

Problem setting and research objective

Aquaculture uses a large variety of technologies – from artisanal to highly-industrial – encompassing vessels and equipment as well as fishing gears and methods. The technological development and widespread use of synthetic fibers, hydraulic equipment for gear and fish handling, electronics for fish finding, satellite-based technology for navigation and communications, onboard conservation, and increased use of outboard engines have all contributed to the major expansion of aquaculture in recent years – particularly in small-scale fisheries. Technical advances

have generally led to more efficient and economical fish farming, reduction of the physical labor required per unit of output, and improved access to resources, but the reverse is the case in the study area.

Where there has been technological backwardness, the greater efficiency of aquaculture production has sometimes led to uneconomical production (overfished) and environmental degradation. This points to the need to develop more effective fisheries management frameworks, together with safer and more environmentally-friendly methods of production, for example, in developing selective fishing gear and in designing aquaculture systems that reduce their impact on external environments which are achievable through technological development in all stages of aquaculture production system ranging from proper setting and construction of pond, stocking management, types of aquaculture production, space selection, fingerlings production, fish health management, fish feed production, fish feed formulation, fishing gears construction and maintenance, harvesting, processing, preservation, transportation, distribution, and marketing. However, for the purpose of this research work, the scope is limited to pond design, construction, and management technology aspects of aquaculture production in the study area.

The application of technical know-how in fish pond design, construction, and management is below average in the study area in spite it location within an area that met environmental requirement for fish farming specifically in term of soil, water, and temperature which constitute critical factor input in fish pond design, construction, and management. Thus, there is a need to close the gap between factor endowment and technological development in the study area. In equal distribution of education, skill acquisition training scheme and poor educational background are considered contributory factors to the technological backwardness in addition to ignorance by the majority of the importance of education and technology to the development of the sub-sector in the study area.

In view of the above while noting that many aquatic resources are overfished and that the fishing capacity presently available jeopardized conservation and rational use as a result of technological underdevelopment thus the need for technological development and or changes in the existing technology to further increase fishing capacity but such technological development or changes should be implemented cautiously; most importantly bearing in mind the improvement of the conservation and long-term sustainability of living aquatic resources, prevention of irreversible or unacceptable damage to the environment, improvement in the social and economic benefits derivable from fishing, and improvement in the safety and working conditions of fishers in general either directly or indirectly are important. The problem of negative effects of fisheries technology on the environment and on species especially non-target species should be recognized which are often ignored in the development of technology or in the technological review processes as applicable. Therefore, certain technology may be undesirable as a result of their disastrous effect because implementation of such technologies may lead to waste of resources.

This research work was undertaken with the main objective of assessing the level of aquaculture technology with reference to fish pond design, construction, and management technology in Maiduguri Metropolitan Council (MMC), Borno State, Nigeria.

Data collection for the research work was carried out from "1st to 31st October 2023," the period Federal College of Freshwater Fisheries Technology (Baga) Maiduguri, Borno State of Nigeria in collaboration with the Federal Ministry of Agriculture and Rural Development (Abuja) of Nigeria through the agricultural research council of Nigeria (Abuja) annually organizes a national training workshop on aquaculture entrepreneurship development for 300 unemployed youths in the country, Nigeria. This has contributed immensely in the pilot stage of the data collection exercise which had facilitated the conduct of the research work and contributed positively on the research outcome.

METHODS

The study was carried out in MMC of Borno State, North Eastern Zone of Nigeria. Borno State has an area of 61,43,589 km and is the largest state in the Federal Republic of Nigeria in term of land mass. The state occupies the greatest part of the Chad Basin and shares borders with the Republic of Niger to the North, Chad to the North - East, and Cameroon to the East. Maiduguri, the Borno state capital is also known as Yerwa geographically, located at co-ordinate 11°50' 13°09' E. It occupies an area of 50,778 square kilometers. Maiduguri is estimated to have a population of 2,607,497 as at 2014 and presently 3.7 million dues to the recent past unrest that pushed the rural population to Maiduguri. The main tribes in Maiduguri include the Kanuri, Shuwa Arabs, Bura, Marghi, and Fulani ethnic groups. Maiduguri, the state capital shares boundaries with Konduga local government area to the North and North West and Jere local government area to the South. Majority of the inhabitants are farmers, fishermen, traders, or civil servants [5]. In Maiduguri, the wet season is hot, and mostly cloudy and the dry season is sweltering and partly cloudy. Over the course of the year, the temperature typically varies from 58°F to 106°F and is rarely below 52°F or above 110°F. The hot season lasts for 2.4 months, from March 13 to May 26 with an average daily high temperature above 102°F. The hottest month of the year in Maiduguri is May, with an average high of 103°F and a low of 79°F. The cool season lasts for 2.1 months from July 20th to September 23rd with an average daily high temperature below 92°F. The coldest month of the year in Maiduguri is January, with an average low of 59°F and a high of 92°F. The rainy period of the year lasts for 6.0 months, from April 22nd to October 21st, with a sliding 31-day rainfall of at least 0.5 inches. The month with the most rain in Maiduguri is August, with an average rainfall of 6.0 inches. The rainless period of the year lasts for 6.0 months, from October 21st to April 22nd. The month with the least rain in Maiduguri is January, with an average rainfall of −0.0 inches [6].

The targeted population for the study consists of 3,700, 000 persons in the study area. 9,00,000 fish farmers were selected from the lists of participants that have undergone unemployed youth training workshop on fish farming in the Federal College of Freshwater Fisheries Technology, Baga, Maiduguri, Borno State of Nigeria. Based on the list of 9,00,000 farmers, comprised youths were trained within the period of 3 years on annual basis from the year 2019 to the year 2022, 50 respondents were drawn from each year ranged; the year 2019–2022, a sample frame of 100 and 150 respondents was formed. The formation of the 100 and 50 respondent as a sample frame was not randomly selected but was based on the selections of farmers registered under the consultancy service of the Federal College of Freshwater Fisheries Technology Baga, Maiduguri, Borno State, Nigeria, assigned to three supervisors (staff of the institution) as extension officers comprised three sub-samples as sample groups of 50 respondents each headed by an extension officer.

Survey method of data collection was employed (direct survey) that the fish farmers were met at the farm site where production occurred. The data for the study were collected from both secondary and primary sources with aid of checklist. This has enabled the acquisition of accurate information on the farm such as the types and the standard of the farm equipment in used. Self-reporting through administrative sources (off-site) contact method was also applied for this study as information was obtained from the consultancy unit of the Federal College of Freshwater Fisheries Technology, Baga, Maiduguri in the fish farmers logbooks, diaries, harvest cards, farm-fixed assets capacity, and farmers socioeconomic characteristics as applicable.

Each of the three extension officers were assigned sub-sample frame primarily constructed for the survey of the fish farms on the formulated survey checklists as follows:

1. Identification of facilities from administrative records of the farm in the fisheries institution and in the farm records
2. Direct enumeration of facilities in the farm

3. Interviews with the fish farmers, staff of the farm, and other related members of the farm either directly or indirectly on matters connected with harvested species, permanence of equipment, the permanence density, the size of the operation, and on variables connected with environmental and ecological effects of the farm.

The information obtained from the sub-set surveys of the three extension agents were combined into an overall procedure after an overall aggregate of 30 farmers were selected from each sub-set survey making a sample frame of 90 fish farmers for the study and was readily integrated into systems; both quantitative, qualitative, and descriptive techniques of data analysis were applied to assess fish pond design, construction, and management technology in the study area. Among the 90 respondents, few have undergone a formal system of education in fisheries technology and have gathered experience in practicing fish farming.

The table below shows an average standard set of quantities of material requirement for the construction of two concrete ponds in the study area.

Other technological aspects of the pond design, construction, and management of fish pond have been incorporated in the respondent's survey checklist and the information obtained presented in the results and discussions.

RESULTS AND DISCUSSION

Assessment of fish pond design, construction, and management technology in the study area

Majority of the fish farmers do not have adequate knowledge of the types of soil suitable for fish pond construction as such the farmers are not conversant with the type of soil for the location of fish pond. This is an important aspect because soil on which pond is located determines the fertility of the pond, productivity, and management in a facilitated manner, although, concrete pond is use and it construction is with complete plastering of pond wall and bottom flooring; therefore, the impact is less in the study area. The fish farmers are conversant with the selection of site for construction of fish pond. The farmers before embarking on construction of fish pond select site with an adequate water supply and ensures the water use in the site must be free from substances either in solid or effluent form considered harmful to the fish, sources of water as rain water, reservoir, dams, river and stream lakes, boreholes, and well. Nevertheless, the farmers consider a regular supply of water to the pond in selection of site for construction that is any irregularity may distract production process. The farmers allow oxygenation and chlorine content to evaporate by allowing the water to remain for 24 h before usage.

Table 1: Quantity of material requirement for the construction of two concrete ponds (6×5×1.3 m) in the study area

S. No.	Material	Quantity
1.	9 inch cement block	500 Pieces
2.	Cement	48 Bags
3.	12 mm rod	24 Pieces
4.	¼ Rod	30 Pieces
5.	Binding wire	4 Rolls
6.	Sand (river)	1 Tipper
7.	Plank (wood)	21 Pieces
8.	Broken blocks	1 Tipper
9.	Nail (3 inch)	5 kg
10.	PVC Pipe (3 inch)	4 Pieces
11.	Elbow joint (3 inch)	6 Pieces
12.	Stop cork (3 inch)	2 Pieces
13.	Tee joint	1 Piece
14.	Top gum	1 Tin

Source: Field survey, 2023

This result shows consistency with the findings of [7] appropriate soil management that will increase soil productivity, including pond culture area, through minimum input and actions which will not lead to environmental degradation.

Most of the fish farmers do not know the scientific implication of the shape of the land on site selection for fish pond construction such as the effect of topography or landscaping and gravitational supply of water. The few of the skilled fish farmers educational and experience wise are of the point that topography or landscaping of the site for construction of fish pond should be sloppy and unexposed to soil erosion and the pond site should be at a lower level than the point of water source to allow gravitational supply of water to the pond. The skilled fish farmers further stressed that the study area land is flat, gravitational consideration in the selection of site for pond construction has less impact as mini slope is provided under the supervision of fisheries personnel or been guided by experience fish farmers while selecting site for pond construction in the study area.

This result is in line with the findings of [8] soil that is a major production factor in brackish water pond because it affects water quality, biological processes, and pond engineering.

The fish farmers have the knowledge of a good road network that create access to farm, feeding habit of the community based on the scale of production of individual farmers, harvesting period in line with marketability, types of labor needed skilled and unskilled labor, and electricity supply in the selection of site for fish pond construction but only few farmers are aware of the level of vegetation as factor to be considered in the selection of site for pond construction as majority of the farmers are ignorant of the fact that the level of vegetation is determinant factor not to talk of financial implication for clearance of the proposed site for construction of the pond by extension (the thicker the vegetation cover of the land the higher will be the cost vice versa).

This result confirms to that of [2].

Majority of the fish farmers are not in better capacity to directly design and construct fish pond at their own individual level; hence, the farmers are not in a position to plan the layout of the fish farm as well as the fish pond which requires survey of the land before the commencement of the pond construction. Under this circumstance, the fisheries personnel and the skilled fish farmer cater for this requirement as they are aware of its importance in minimization of the cost of construction. The farmers have knowledge of the material requirement for the construction of the fish pond unlike the knowledge of designing and construction of the fish pond. The materials involve in the construction of fish pond in the study area which includes diggers or mechanical excavator, grader (manual), compacter (manual), shovel and spade, water control system (ball gauge for polyvinyl chloride [PVC] pipes), PVC as drainage facilities, tapes 50–100 and 5–15 m portable tapes, plums (bricklayers/leveler), pegs, ropes, and markers. The farmers are very conversant with material requirement as a result of the farmers many years of fish farming experience but yet the farmers lack full knowledge and techniques of construction of concrete fish pond except the few skilled farmers and other fisheries personnel of the Federal College of Freshwater Fisheries Technology, Baga, Maiduguri give explanation demonstratively base on the materials required for the construction of concrete pond. The materials required includes; bindings wires, timber planks, nails, plumbing materials (PVC pipe and gate valves), concrete blocks (6-9 inches hollow or non-hollow), sharp/river sand, fine sand, gravels or stone chips, and enforcement bars (rods) among others.

This result agrees with the finding of [9] that majority of the farmers have basic level of education and averagely have farming experience and there exist significant difference with the farmers that have attained at least intermediary and or advance level of education as a result of urban settlement compared to the less educated farmers that migrated from villages to the study area.

Fig. 1: Placement of drainage pipe, cement-stone chips, sand mixer, and casting of floor slab in the study area. Source: Field survey, 2023

Fig. 2: Concrete block foundation with enforcement bar and hardcore in the study area. Source: Field survey, 2023

Fig. 3: Well manage newly constructed concrete fish ponds in the study area. Source: Field survey, 2023

Fig. 4: Concrete fish pond ready for stocking in the study area. Source: Field survey, 2023

The few skilled farmers and the fisheries personnel of the Federal College of Freshwater Fisheries Technology, Baga, Maiduguri responded; with the aid of demonstration; concrete pond foundation is constructed with concrete block with enforcement bars and hardcore required under the ground level below formation of the floor slab and the walls. On top of the concrete pond floor slap, concrete pond walls are built after placing the water outlet pipes. Preferably, the outlet pipe is place below the slab with an elbow joint. The concrete pond floor slap is made from cement, stone chips, and sand in a proportion of (1:2:4) which is thoroughly mix manually in the study area but in other areas, mechanical mixer may be applied. The thickness of the concrete slap is between 7.5 and 10 cm (Fig. 1).

This result confirms to that of [10] to prevent excessive seepage, reduce the permeability of the soils to a point at which losses are insignificant depends largely on the proportions of coarse-grained sand and gravel and of fine-grained clay and silt in the soil.

The application of the hollow block requires filling with a mixture of cement, gravel, and watery cement (mortar). The height of the wall is at 1:2 m wall, the water inlet structure is installed before the blocks that will make the height to 1.5 m wall will be built on. The wall of pond is plastered with not <2 inches and or 5 cm thickness with highly concentrated mortar from cement and sand in a proportion of (1:2) and or one bag of cement to six tubes of sand, respectively. While constructing concrete fish pond the fish farmers ensure the four corners of the pond is well reinforced (built in form of pillars) because these are the likely points of linkages, if care is not well taken (Fig. 2). The farmers splash water over the newly constructed pond twice in the morning and evening every day for 3 consecutive days for curing. Alternatively, the learned fish farmers cure the pond by hanging wet jute bags on the wall of the pond and on the floor of the pond about 2 cm water depth for at least 7 days before stocking the pond and a pipe for draining an overflow of water is installed on the upper part edge of the concrete pond to drain and prevent overflow of water in case of heavy rainfall or excessive inflow of water into the pond in the study area (Fig. 3).

This result is contrary to the findings of [11] using waterproof linings, which is another method of reducing excessive seepage in both coarse-grained and fine-grained soils. Polyethylene, vinyl, butyl-rubber membranes, and asphalt-sealed fabric liners are gaining wide acceptance as linings for ponds because they virtually eliminate seepage if properly installed.

In managing fish pond, the farmers remove the pond water completely through the pond outlet while preparing the pond for stocking. Thereafter, the pond will be allowed to dry depending on the prevailing weather condition. The farmers are of the point that drying of pond inner surface is practically cheap and effective method of eliminating unwanted organisms in the pond before culture period**.**

This result confirms that of [12] conditioning in aquaculture reduces the mortality rate due to predation with little additional effort.

Method applied by the fish farmers in the management of pond for successful fish production is by washing thoroughly and carefully a newly constructed fish pond (concrete) with the use of clean water and salt. According to a few of the learned fish farmers, this method of washing will release excess lime into the water considered toxic to the fish. Under this management system, the farmers will fill the pond with water; the water will remain for good 72 h (3 days). The same refilling stage will be repeated for the 2nd time to stay for the same period of 72 h (3 days). Thereafter, the fish pond is flush thoroughly; hence the pond will be filled with water again and again by the farmers until the required pH for the pond is obtained which is normally carried out with the intervention of the learned fish farmers in the study area.

Under the circumstance of old or already existing pond all that is done by the farmers in the study area is to wash thoroughly and scrub with detergent (mild) with the use of excess water to enable the pond to become clean and safe for fish stocking (Fig. 3).

This result agrees with the finding of [13] introduction of aqua mimicry enable the appearance of planktonic organism's act as the supplementary food for the shrimp and through the proliferation of beneficial bacteria in aqua mimicry system, it helps to stabilize the water condition and accelerate the growth performance of the shrimp as well.

The fish farmers in the study area involve in other pond management activities in concrete pond fish production such as the technique of filling the pond with water which is carried out slowly and gradually if not the bottom of the pond will be affected overtime which will have repercussion effect on the durability of the pond. According to some of the few experiences and learned fish farmers, filling of pond with water is between 1.5 and 2.0 m level in readiness for stocking as the fish farmers do not have problem of source of water for impoundment having borehole as source of water as the area is not close to river and or stream. Thus, the fish farmers stand at a better chance to stop the farm been infected by diseases in the study area (Fig. 4).

This result is in line with the finding of [14] majority of (80%) of the source of water used in the farms was shallow well/boreholes which may be attributed to; the locations of most ponds were far from rivers, streams, and canals, meet water quality needed for the farm operations, for easy access and convenience and to avoid introduction of predators, diseases, and pollutant into fish farms.

There are other pond management activities that majority of the fish farmers in the study are not conversant with its practices but are of the view that the few fish farmers in the study area that has been in fish farming for many years and has undergone formal system of education related to fisheries technology are in a better position to give vivid demonstrative explanation pertaining those pond management activities. The few experiences and learned fish farmers in the study area responded on such activities as the application of various acid – neutralizing compounds of calcium or calcium magnesium for enhancing the effect of fertilization, prevent wide swings in pH and also adds calcium and magnesium which according to them is important in animal physiology, this process is said to be liming. As spelt out, the common lime use in pond preparation and application rates are quick lime or slake lime 20–50 g/m^2, agriculture lime 50–200 g/m^2. The ground and powdered lime are broadcast over the entire dried bottom of the pond by the farmers and to allow dry on the soil for 14 days. Thereafter, the pond is flooded up to 60 cm (above the knees) in the study area.

This result shows consistency with the finding of [15] that liming improves water quality and yield benefits for aquatic habitats provided that the water quality improvements are sustained.

The few experiences and learned fish farmers improve pond fertility and stimulate plankton production to stimulate natural fish food production such as inorganic manure (NPK, single super phosphate, triple super phosphate [TSP], etc.) or higher concentration on animal manures which includes cow, pig, and poultry. The fish farmers apply the manure to a flooded pond to stimulate natural fish food production, this process is said to be fertilization. Under the application of inorganic manure, the farmers fill a jute bag with fertilizer and submerge it underwater, or they dissolve the fertilizer inside a plastic bucket and sprinkle it over the entire surfaces but in-case of organic manure, the farmers fill a jute with the manure and tie to the stake at various points in the water. Whereas some of the farmers collect manure in a large tank mix with a reasonable quantity of water, after mixing, apply the liquid part of the mixture in the fish pond. The ratio of its application by the farmers in the study area is as follows; cattle dung (100 g/m^2), chicken (50 g/m^2), and TSP (5 g/m^2) once in 2 weeks period.

This result shows consistency with the finding of [16] that the most common supplementary feed presented was corn bran vegetables and food scraps. <1% of the farmers used prepared feed. Other feed sources were primarily cassava leaves and termites. Only 1% of the farms apply fertilizer to the ponds; fertilization of the pond with manure.

Majority of the fish farmers in the study area regardless of their level of formal system of education in the aspect of fisheries and aquaculture have the skill of assessing the quality of fish seed to be stocked, the size and number of fingerlings to be stocked as per the size of the fish pond have the knowledge of transporting fingerlings, and conversant with techniques of stocking fish into the pond and sorting as well as grading. The farmers are also better up in water quality management except under necessary condition intervention is required. This is as a result of the fact that majority of the farmers in the study area have put in many years of experience in fish farming and the farmers work hand in hand with their colleagues skilled fish farmers and are able to undergo youth empowerment and capacity training on fish farming in the study area.

This result confirms to the finding of [9].

SUMMARY AND CONCLUSION

The focus of the study is an assessment of aquaculture technology in the aspect of fish pond design, construction, and management in Maiduguri, Borno State, Nigeria. The finding of the study reveals; the fish farmers are in better position in site selection for the construction of fish pond in line with the determinant factors as access to required water, road network, and marketability among others except that of vegetation requirement. The fish farmers are capable in managing fish pond management activities in the study area. The farmers are not in a better position in the identification of types of soil for the location of pond and not conversant in determining technical implication of shape of the land on site selection for fish pond construction. The fish farmers are not adequately equipped in planning for the layout of the fish farm and the fish pond before the commencement of construction work. The development of the of the fish pond is carried out with the aid of the learned and experience fish farmers as well as the fertilization and liming of the fish pond in the study area. The study recommends:

1. Effort should be intensified by both government, non-governmental organization, and community members for intensive training of the fish farmers to acquire adequate knowledge of fish pond design, construction, and management technology in the study area
2. Encouragement of the fisheries technicians, technologist, and the professional that do not directly involve in farming practice to directly engage in fish farming for the enhancement of rapid development of the sector
3. The need for expansion of research in the sub-sector geared toward bringing new ideas and innovations for rapid technological development in a sustainable manner.

AUTHOR'S CONTRIBUTION, CONFLICTS OF INTERESTS AND AUTHORS FUNDING

Contribution, conceptualization, writing original draft preparation, writing review, and editing by Babagana Zanna. The author has read the manuscript and agreed for onward vetting, corrections, guidance for further consideration and approval, and subsequent publishing of the final version of the manuscript accordingly. The research work was carried out by Babagana Zanna without any financial support from any agency or individual, and finally, the research work has no any conflicts of interest.

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