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NIGERIAN AQUACULTURE: STATUS, PROSPECTS, AND FUTURE GROWTH

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By: Adam, Rahma
Title: A gendered aquaculture value chain study in Nigeria

Along the aquaculture value chain, what is the status of gender equality, participation, engagement and benefits received by women and men who are involved in various nodes of the aquaculture sector in Nigeria; and what are the barriers or opportunities that are presented to various aquaculture value chain actors in the country? Data were collected using mixed methods, including a survey of 433 fish producers, input suppliers 57, market actors 183, we also collected semi-structured key informant interviews and focus group discussions with men and women aquaculture value chain actors in Delta and Ogun states. The findings show that fish input suppliers, farmers and service actors are mostly focused on African catfish and Tilapia. Payment terms with their customers are made using cash or mobile transfer. Fish seed producers and suppliers do not provide their products on credit terms. The majority of input supply businesses and farms are owned by men. Women were mostly found in the marketing of fish and did not engage in hatchery business due to their responsibility towards their household work. Men have more capital and are less expected to care for their household chores, which were the primary motivators for their business ownership. Other factors that constrain the work that the informants perform include lack of funds or money (including high cost of feed), availability and accessibility of inputs, unstable electricity, and poor transportation. These and other constraints are reported to be the same for women and men. COVID-19 affected the informants (all the value chain actors) and has affected their affordability of food products due to the increase in their prices. Some resort to eating more carbohydrates than any other food group and reduce the quantity of food they consume when they are not able to afford or access their regular food. Furthermore, the pandemic also affected their businesses.

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By: Adeniyi, Marcus A.
Title: Feed Supply: Constraints Faced by Smallholder Farmers

I. INTRODUCTION

Fish are the most efficient animal to produce, as the Feed Conversion Ratio (FCR) is so low. FCR is the amount of food an animal has to consume in order to gain one kg of body weight. On average, farmed fish requires 1.1 kg of feed to gain 1 kg of body mass, compared with 1.7 kg for poultry and 6.6 kg for cattle.

Feed constitutes up to 60 percent of total operational costs in aquaculture production (Ozigbo, et al., 2014). Unfortunately, this number is increasing since the aqua feeds business is facing numerous obstacles, such as a shortage of feed materials and a lack of skilled workers.

Small-scale fisheries on the other hand, contribute significantly to the global supply and production of seafood. It is estimated that small-scale fisheries from developing countries produce half of the world's fish landings (FAO, 2018). However, as aquaculture production continues to grow, the need for high-quality fish feed also increases. Hence, the fish feed industry is constantly evolving and introducing new products. Some of the latest trends in fish feed especially, at smallholder level is the use of alternative proteins (E.g. Black Soldier Fly, Maggot Algae) as well as the development of specialized feeds for different species.

II. FISH DEMAND VERSUS SUPPLY

The awareness that fish is among the healthiest foods around the globe, coupled with the increase in human population has resulted in an increase in demand for fish and fish oil. Report had it that about 40 percent increase in fish demand has been recorded between 2000 and 2015 while about 35 percent increase in deficit over same period was anticipated (FDF, 2008). With the current consumption rate of over 1.5 million tons of fish per annum (CBN 2016) there is still a wide gap between demand and supply which must be filled if Nigeria is to achieve food security. Small and Medium Scale Enterprises (SMEs) when combined with artisanal fisheries that contribute about 82 percent of the domestic fish production. However, as catch from the wild is dwindling, aquaculture remains the only alternate source of fish and other aquatic products for human consumption. Globally, the projected fish supply from fish farming stood at 50 percent by 2020. This trend provides an impetus to intensive fish farming in Nigeria strongly supported by a viable aqua feeds industry (EDR, 2014).

III. HISTORICAL STATUS OF NIGERIA AQUA FEEDS INDUSTRY

- Past Status of Aqua Feeds Industry

  According to UNCTAD/GATT (1984), total production of compound feed in Nigeria was estimated at around 800,000 tons in 1981, 600,000 tons in 1982 and 400,000 tons in 1983. The decline has been attributed to the serious domestic economic crisis prevailing and its impact on the livestock sector. The approximate shares by feed type in total output during these years were as follows: Poultry feed, 90 percent, cattle feeds, 7 percent, feed for pigs and other animals, 3 percent. Production was projected at estimated 480,000 tons at end of 1984. By 1986 demand for compound feeds from industrial livestock farms (of which 90 percent will be commercial

poultry operation) would climb to about 600,000 tons of poultry feeds and 90,000 tons of feed for pigs and other animals, or a total of 690,000 tons. During these years, the contribution of aqua feed to the total animal feed production was very negligible. It was grouped among the three percent contribution by pigs and other animals. Of the 350 feed mills registered in 1983, only 185 were operating in mid-1984. Their total production capacity was 1.2 Mt of compound feed annually. In 2000, an estimated 35,570 tonnes of feed were used by the Nigerian aquaculture industry (Fagbenro and Adebayo, 2005). This quantity still represented a negligible proportion (< 1 percent) of the national feed production. However, aquafeeds industry has started to gain recognition. A projection of future aquafeed requirements for 2015 suggests that at an annual growth rate of 10 percent, Nigeria would have the potential to produce sufficient aquafeeds using existing production capacity.

- Present Status of Aqua Feeds Industry

  Nigeria has significantly improved in the area of aqua feeds production between 2014 and 2015. Nigeria is now rated as one of the largest emerging animal feeds producers in the world with the potentials for commercial production. In 2015 the Nigeria's animal feed sector has been rated as number 40th in the world; moving 11 steps forward from its previous ranking of number 51 among the 130 leading animal feeds producing countries in the world. Nigeria is estimated to have produced 3.8 million metric tons (MT) of animal feeds in 2014 and 5.3 million MT of animal feeds in 2015 with aquaculture contributing 12 percent second to poultry production. The aqua feeds industry is experiencing rapid growth. However, production capacity cannot match the ever-increasing aquaculture production, which is largely in the hands of smallholder, thereby resulting in a whopping 75 percent importation of the total aqua feeds required by the fish farmers in Nigeria. Admittedly, this problem needs urgent attention.
  Trend analysis of the potential of Nigeria aqua feeds industry indicated that, there was a dwindling production capacity in the 80s, a sharp increase was noticed in the 2000s when production capacity of 35,570 tonnes of aqua feeds was recorded while production stood at 10,760 tonnes. Recently, Nigeria is estimated to have produced over 700,000 MT of aqua feeds. In addition, the industry is plaque with lack of feed ingredients: Indirect devaluation of naira has a serious negative impact on the prices of ingredients as well as, inadequate supply of maize and soybean (partly due to continuous insecurity), which are also competed for by humans and livestock.

IV. AQUA FEED SUPPLY ANALYSIS AND IMPLICATION TO SMALLHOLDER FARMERS

In Nigeria, the aqua feed industry is dominated by few large commercial feed industries usually based in Europe, Asia or America who run local franchised industries, and many unorganized toll millers. Currently, emphasis has been placed on encouraging indigenous feed enterprises that make use of local ingredient in formulating feeds for the fish industry. The task of meeting the increasing demand for fish feed can best be realized through increased availability of indigenous feed production. Indigenous Feed Enterprises are seen as an honest approach because of ease of availability of raw materials, and access by fish farmers. Several strategies have been adopted such

as price policies, input subsidies, production credit and liberalization by governments and individuals to increase the output of these fish feed enterprises, yet their performance is low in terms of meeting the needs of the fish industry. Interestingly, the request for the products of the enterprises is daily on the increase (EDR, 2014). Two types of aquafeeds are used to culture fish in Nigeria. According to Ibiyo and Olusegun (2005), these are On-Farm Feed and Commercial/ Aqua feed.

- On-Farm Aqua feeds

  These are farm made feeds. Farm feed makes up a staggering 70% of the estimated 35,570 tons of aqua-feed that were produced in 2000. On-farm feeds are usually made up of native feedstuffs fed as blended, doughs or compressed pellets. The quality of farm made aquafeeds depends on the method of formulation, ingredient quality, availability and affordability; and the processes of manufacture. In Nigeria, farm made aqua feeds are cheaper than commercial aqua-feeds, hence, smallholder farmers have preference for them.
- Commercial Aqua Feeds

  Commercially manufactured aqua feeds are feeds that are formulated to meet the nutritional requirements of a distinctive fish species and their different life stage. Two forms of commercial aquafeeds have been identified:
  - Locally manufactured: Nigeria is rapidly gaining access to locally manufacturing capacity and consequently, many local feed millers are producing some fish feeds. These company include: CHI, Grand Cereals for Vital Feeds and Aquamax, Olam, etc.
  - Imported commercial feeds: Nigeria imports aqua feeds amounting to an estimated 75 percent of the total feed production. Nigeria imports between 700,000 and 900,000 metric tons of fish annually. Imported feeds are all high-quality floating feeds. Aller-Aqua is one of the leading company supplying commercial feeds to Nigeria.

V. CONSTRAINTS FACED BY SMALLHOLDER FISH-FARMERS

The main challenges faced by the Nigerian aqua feeds industry are:

1. High Cost of Feed Ingredients: This constitutes about 60 percent of the total constraints. The major ingredients in aqua feeds are fishmeal, soybeans and maize. The fishmeal and soybeans provide both animal and plant-based proteins, while maize provides energy. However, the percentage inclusion of energy in fish feed ration is less than 5% and farmers can bear with this in terms of cost/price and possibly as an input from the mixed farming operations. Most of the smallholder farmers have maize farms directly or as cooperative, hence, they alleviate the high cost of maize ingredient through direct inclusion. On the other hand, indirect devaluation of the naira has also result in hike of raw material prices, particularly fishmeal, which is about 75% inclusion for aquaculture production. Thus, farmers have provided resilience strategy by substituting fish meal with Maggot, or Black Soldier Fly (BSF) to provide animal protein need to their feeds.
2. Lack of Knowledge and Trained Personnel in Areas of Aquaculture Nutrition: This is another constraint plaguing the productivity of smallholder. Feed formulation and processing, and machine operators are constituting about 27 percent of the constraints. As much as the farmers want to safe cost by using toll milling facilities, there is still a problem of lack of technical capacity by the farmers as well as the toll millers. Hence, the quality of feed formulated distort the productivity of the farm.
3. Lack of feed ingredients: This is another constraint, constituting about 14 percent.

Inadequate of raw material for production, increased rivalry between humans and animals for energy sources, and the usage of traditional feed components are the main causes of feed ingredient shortages.

4. Feed transportation, storage and handling: The tripartite constraints factors impair the productivity of smallholder. Transportation, often refers to as logistics need, is needed for movement of both input and output to and from the farm. But due to poor infrastructural development in the country, farmers are paying heavily for this. Also, most farmers are generally not aware of the importance of proper handling of fish feeds. Inappropriate application of transportation techniques, handling and storage of fish feeds degrades the quality of the feeds. For example, transporting feeds in open trucks, motorbikes and bicycles expose the products to high moisture content, therefore, enhancing the chances of infection by fungi. On the other hand, prolonged storage in unfavorable conditions also may lead to infestation by pests, which negatively impact on feed quality and yield low fish production (Awity, 2013). In summary, inappropriate feed storage conditions lead to nutrient losses, feed spoilage, lower fish yields and poor economic returns.

5. Lack of Quality Assurance: Examples are (i) Re-bagging (ii) Expired feeds, (iii) Adulterated feeds

6. Climate Change

7. Lack of Credit Facilities

VI. CONCLUSION AND RECOMMENDATION

With the rapid growth of aquaculture, and to bridge the gap between importations of aqua feeds which is about 75 percent. There is need for deliberate innovation development of locally available feed ingredient as substitute to fish meal. This innovation could be advanced through developmental programs that will dovetailed into Innovation Platforms (IP), where different stakeholders; researchers, government agencies, aquapreneur, processors, nutritionist, marketers and financial institutions, farmers and users of aqua products, etc., will work on solutions to various identified problems. This IP can as well solve the problems of increasing demand for feeds ingredients, enhance income earning of the small holder farmer, add to GDP and reduce poverty in a sustainable manner.

By: Adeyemo, Olanike K.

Title: Improving Aquaculture Biosecurity in Ogun And Delta States: The Status on Circulating Pathogens

Fish Innovation Lab Aquaculture Biosecurity Project Team

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Intensive fish culture precipitates stress from overcrowding, poor water quality, etc. The resultant effect is diseases and economic losses. The ability to curtail, contain and eradicate diseases of fish when they occur will depend on several factors bordering on biosecurity measures. Biosecurity has been defined as a strategic and integrated approach for the analyses and management of relevant health and environmental risks to human, animal, and plant. Our project is aimed at Improving biosecurity using a Science-based approach to manage fish disease risks and increase the socio-economic contribution of the Nigerian catfish and tilapia industries. The aspect of the study being presented is geared towards identifying pathogens of socio-economic significance circulating in Nigerian catfish and tilapia aquaculture using presumptive field and laboratory diagnostics, include whole genome sequencing.

Five and three consenting fish farm clusters were recruited into the study respectively in Delta (Ughelli North, Ika South, Isoko/Warri, Uvwie and Oshimili South) and Ogun (Eriwe, Ilase and Ikenne) States. Field sample collectors were trained to collect screening samples seasonally, while resident Veterinarians were designated to visit farm clusters monthly and during disease outbreaks to collect samples from moribund and/or apparently sick fish. Presumptive and laboratory diagnoses were carried out in Fish and Wildlife Disease Laboratory, Department of Veterinary Public health and Preventive Medicine, University of Ibadan. Organ Samples (liver, kidney, and spleen) were processed according to standard bacteriological standards.

One thousand, eight hundred and forty-one isolates were recorded from the screening samples comprising ten gram-negative and three gram-positive bacterial organisms. The gram-negative isolates across seasons in both Ogun and Delta States were Klebsiella aerogenes (8.2%), Edwardsiella species (*E. tarda* (10.9%), and *E. ictaluri* (0.2%)), Salmonella species (1.2%), Aeromonas (*A. hydrophilia* (7.7%), and *A. caviae* (1.8%), Vibrio (*V. parahaemolyticus* (14.0%), *V. cholera* (10.4%), and *V. metschnikovii* (0.1%)), *Flavobacterium columnare* (4.6%), *Pasteurella piscicida* (10.1%), *Pseudomonas aeruginosa* (3.9%), *Shewanella putrefaciens* (3.2%), and *Plesiomonas shigelloides* (0.7%) while the gram-positive organisms across seasons were Lactococcus garvieae (3.5%), Streptococcus (*Streptococcus iniae* (7.4%), *Streptococcus pneumonia*

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(6.0%), Kocuria species (6.2%). State and seasonal skew in circulating pathogens was also observed.

The isolation of commonly reported fish pathogens represents a bottleneck for the sustainable development of the Nigerian aquaculture industry. Prevention, early recognition, prompt diagnosis and rapid intervention are the best steps to manage aquatic animal diseases. Fish microbiological safety is a concern for consumers, industries, and regulatory agencies worldwide. The presence of pathogens (*Salmonella sp, Vibrio cholerae*, etc) responsible for severe foodborne infections in humans portends significant public health risk. Aquaculture practices are essential for meeting global seafood demands; this result therefore has consequences for Nigerian aquaculture products and by-products in global trade. Practicing biosecurity management will reduce disease-related production losses and suboptimal yields at farm level and is hereby recommended. Additionally, research into the presence of antibiotic-resistant strains and transference of resistance genes among the aquatic microbial population in the Nigerian aquaculture industry is hereby justified.

By: Agbato, Olubunmi Adedayo

Title: Improving Post Harvest Food Quality and Safety
Processing, value adding and marketing of fish products: SME perspective

Fish Processing refers to the processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the customer. Fish in its raw state and dried state harbor microorganisms, some of which are pathogenic in nature. Deterioration of smoked dried catfish can be reduced by right processing methods and value addition and subsequently curb loss of quality in the fish. Value addition to fish products will increase acceptance, reduce post-harvest loss and maximize profitability.

In high-income countries, SMEs constitute 67 percent on average of the formal employment in the manufacturing sector and 45 percent in developing countries. Similarly, SMEs contribute 49 percent on average to GDP in high-income countries and on average 29 percent in low-income countries due mainly to better access to technologies, financial credit and skilled manpower. Profit maximization is impossible without effective fish marketing and the prevailing marketing challenges hindering the exploitation of its potentials.

This presentation will look into the processing methods, product development (value addition) and marketing of products from the small-medium enterprise perspective. Adding value to fish is a strategy to attracts more customers, brings about Convenience, attractiveness, more palatable, and ease of use, It brings about job creation, Effective post-harvest management, Increase shelf life of fish products etc.

Fish marketing involves identifying the right product, the right people, the right place and the right price. The overall marketing system in Nigeria involves the traditional marketing system and the modern marketing system emerging in the urban areas. Poor farm siting, infrastructural development, lack of value addition facilities and high deteriorating nature of fish are some of the constraints of fish marketing in Nigeria.

One of the best ways to improve fish marketing in Nigeria is to learn and assimilate ways of improving her fish marketing system from advanced fishing Nations like Japan, which has a well-organized and developed central fish wholesale marketing network. Additionally, banks and other financial institutions should assist small and medium-scale fish farmers with loans at an affordable interest rate.

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By: Ahmed, Remi

Title: Diversification of Farming Systems and Species in Nigerian Aquaculture (Tandan) Perspective

There are many reasons why we may have to contemplate changing the species of fish we are rearing in Nigeria.

African catfish is our major candidate in Nigeria. Around 1995, when we started modern day aquaculture of African catfish, all the aspect of production was very easy for us. Best management practices principle was upheld.

We hardly use antibiotics.

We are very selective in the usage of brood stock.

The last batch of our fingerlings are always flushed into the gutter.

Today, we apply antibiotics on the fry at even uncalculated quantity. Any available big catfish is used as brood stock.

All the fingerlings from any batch produced continue in the production line.

Our popular candidate is mostly consumed in Nigeria, not acceptable to our neighboring country of Togo, Republic du Benin. It is not popular in Ghana and Cameroun until very recently.

Our candidate is regarded as a very cheap fish. It is been fed with very expensive feed. Even, with very efficient conversion ratio, farmer can hardly make any profit out of their efforts.

The popular rearing system is also not helping the matter.

The concrete tanks, foldable tanks and earthen pond. A lot of expenses are always incurred in the process of refreshen the water by pumping in and pumping out of water, is a lot cost.

The change into cage culture system is always been proposed, it does not required pump in and out of water. No need to change water nor refresh water.

Naturally water comes in and work out of the system with uneaten feed and feacal deposit. Any rearing system that promotes the usage of power is not encourage in Nigeria.

Water re-use system and in – pond raceway system falls into this category. Our tilapia is doing well in cage culture system.

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By: Ajani, Emmanuel K.
Title: The Farm Diversification Process: Adapting Rice Fields for Co-Cultivation of Rice and Fish

The double burden of undernutrition and undernourishment is prevalent in most Nigerian states due to food and nutrition insecurity, un- and under-employment, and inefficient market systems that lead to food losses. These are caused by intertwined factors ranging from poverty, lack of nutrition education, knowledge gap in agriculture/aquaculture practices and inefficient market system. These challenges reflect in the communities in the forms of stunting, wasting and underweight children, un- and under-employment for youths, gender disparity in resource use and allocation, and limited access to food. Rice-fish farming could play an essential role in the fight against hunger, malnutrition and food insecurity due to the rich source of essential macro and micronutrients (protein, fat (poly-unsaturated fatty acids), vitamin (including, vitamin A, vitamin B2, vitamin B6 and others), minerals (iron, calcium, iodine, potassium and other minerals) that could be derived and utilized by the human body from the food products harvested from the farming system. Therefore, farm diversification and an efficient market access system of the diversified farm produce, will increase the food and nutrition security in the target communities, and provide economic opportunities for youths and women if implemented and sustained through efficient management systems.

This research project tackled these challenges in two Nigerian States (Kebbi and Ebonyi), which are within communities in the Nigerian States listed in the USAID Global Food Security Strategy (GFSS) Zones of influence and are important rice-producing areas. These communities benefited from the support of the Federal Government to increase their rice production for national self-sufficiency. This project aimed at introducing a process of farmer-managed farm diversification and intensification in the two Nigerian states (Kebbi and Ebonyi), using an integrated rice-fish farming approach. The objectives of the research are to consider the technologies that are accessible to local farmers, and analyze how integrated agriculture-aquaculture (IAA) systems influence the safety nets, diets diversity, livelihood options, rural employment (especially for youth and women), the use of resources and the role of institutional and policy innovations. It involves business/entrepreneurship study for facilitating market access of farmers' products through the value chain systems, and sustainability and long-term support of capacity development of farmers, extension workers, university students, and value chain actors. This project also provides the template for kick-starting a process of farm diversification and intensification, which can then be maintained by the communities themselves, with the support of local agricultural extension officers and other development partners. Over 200 farmers and 30 extension workers spread across two Nigerian states (Kebbi and Ebonyi) benefited and are trained through the farm diversification process, with 40% of the farmers female and youth. The research involved quantitative and qualitative data collection, stratified to represent statistically representative samples from multiple levels of rice-fish intensification adoption, market access evaluation and gender roles. The major outcomes and outputs of the project include: piloting the evidence-based and locally adaptable cost-effective integrated rice-fish system in target communities; establishment of a functional Innovation Platform on Integrated Agriculture-Aquaculture systems; enhanced entrepreneurship skills of farmers especially youths and women; identification of end market opportunities for IAA farm outputs; farmer and rural household income and employment-creation opportunities for youths and women; manual for small-scale rural farmers that help in the

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development of an investment and business plan; investigation of alternative feed ingredients, value addition method (through fish smoking) and skill-set development in fish seed production among other innovations that are applicable in rice-fish farming; and strengthened partnership between scientists and the development communities for improving food production, nutrition education and capacity development, among others.

At the end of the project, the impact is measured by: the number of farmers that implemented improved methods of production using integrated aquaculture with rice production developed in the project areas and reported contribution of the farm diversification to their farm productivity, income and household/community food and nutrition status. The impact of the project is also measured by the number of end market opportunities developed for the farmers, number of farmers that benefited from the entrepreneurship or business management program component of the project, the number of women and youths that benefited from the project; and the number of farmers, farmer groups, extension workers, students, scientists, and value chain actors that are trained and benefitted from the capacity enhancement component of the project.

The multiple benefits of this project are expected to cover over 800 people which includes direct participating farmers, neighboring farmers, farmer groups, value chain actors, extension workers and university students. The IAA and the business plan models developed through this research could be scaled up and implemented in other parts of the country and within West and Central African countries. The lessons learned from the project are useful in mainstreaming aquaculture into other applicable agriculture/horticulture production systems within and beyond target communities.

By: Bodunde, Olusola

Title: E-AquaHealth Platform: Towards Aquaculture Stakeholders' Engagement and Sustainable Aquatic Animal Health

Fish farming is one of the important and highly valued agricultural practices in Nigeria. Although the intensive farming practice of these farmers have a good promise towards financial and food security, there are major constrains with respect to fish health and health management systems. This ultimately leads to a negative outcome in production and profitability.

As a result of the dearth of professional help, in incidences of outbreak, farmers use unorthodox means of treatment, which leads to the inadvertent use of dangerous and harmful chemicals as well as abuse and misuse of antibiotics which ultimately affects the aquatic environment as well as endanger animal, human, and environmental health. Hence, the need to provide an initiative that aims at connecting farmers to Veterinarians and other stakeholders within the aquaculture value chain.

The e-AquaHealth platform was therefore designed using simple features that would make it easy for those with basic literacy skills to deploy. It is a web-based platform designed to bridge the gap between fish farmers, aquatic veterinarians, and other service providers. It also provides laboratory diagnostic support to enhance the delivery of quality services that enhances the wellbeing of fish and profitability of aquaculture. The platform is also used to provide extension information to fish farmers as well as continuing education resources for aquatic veterinarians.

Keyword: e-AquaHealth, Fish health, Aquaculture, Veterinarian, Disease diagnoses

By: Chadag, Vishnumurthy Mohan
Title: Aquaculture Biosecurity

It is now very well recognized that aquatic foods are essential for Nourishing Nations and transforming Food Systems. Blue Foods Assessment studies and reports have strongly indicated that Fisheries and aquaculture can play a greater role in delivering healthy diets and more sustainable, equitable and resilient food systems around the world. But the main challenge is to transform aquatic food systems to do better for humans (safe/healthy food), animals (no/less disease) and the environment (clean) within planetary boundaries. It is well known that the Global demand for aquatic foods will roughly double by 2050 and aquaculture is predicted to meet most of this demand complementing capture fisheries. It is worth noting that aquatic foods rank more highly than terrestrial animal-source foods in terms of their nutritional benefits and potential for sustainability gains. Aquatic food systems facing the highest risk from climate change and disease are also typically located in those regions (LMIC) of Asia and Africa where people rely on them most and where they are least equipped to respond and adapt to climate hazards and disease risks. If we look at the major trends in aquatic farming systems there is evidence of increasing intensification, diversification of species, diversification of systems, influence of markets, trade and consumption (food safety) and influence of enhanced regulation and better governance. As a consequence, aquatic animal disease emergencies are on the increase and the industry loses close to 10 billion USD annually. Diseases are also a major driver for use and misuse of antimicrobial agents driving AMR in bacterial pathogens of aquatic animals and also pathogens of human health concern. The need for embracing the principles and practice of responsible aquaculture is more now than ever before. Practices and behavior that are in conformity with national and international standards and requirements, that ensure sustainability of the sector, protect environment integrity, enable social equity and respect ethical values and consider human food safety concerns seriously are very much needed. Operationalization of simple and practical national aquatic animal health strategies within the overall One Health framework must be considered on priority in LMIC countries of Asia and Africa that have a stake in the future of aquatic food systems. However, this is not easy in Asia and Africa in view of large number of small farmers, and huge diversity in cultured species and systems. We need to develop system specific and commodity specific practices that are based on science (e.g. risk analysis) and consider production risks, biosecurity risks, social risks, food safety risks, environmental risks and many others. Starting point for most stakeholders in LMIC would be to understand and implement simple farm level biosecurity plans and better management practices.

Farm level biosecurity is a system or procedures to prevent the introduction of pathogens into a farming facility (e.g. ponds, tanks, farm, hatchery) from outside the facility or into a section of the facility from another section in the same facility. It is a common-sense method of prevention to avoid contact between farmed animals and their pathogens (e.g. bacteria, parasites, fungi, viruses). Most of the time it consists of various, simple, sometimes zero-cost measures that will keep pathogens away from farmed fish and keep fish away from pathogens. Underlying principles include three elements. (1) Preventing entry of pathogens coming through various routes – water, stocked material, people, equipment, feed, birds, carriers (2) If pathogens do gain entry- preventing disease outbreak in the facility by following better husbandry, good feeding, good water quality, and stress management and (3) if outbreaks do occur – preventing it spreading to other units in the facility and to outside of the facility by better handling of mortality events, reporting and information sharing, and better disposal of

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dead fish.

BMPs are management practices and are not a standard for certification. When adopted by small scale farmers will minimize disease risks, improve production efficiency, reduce costs of production and maximize economic returns. It is also a PATH towards compliance to environmental, food safety and market requirements and possible participation in certification programs. Key BMPs considered in many farming systems include; good facility preparation, Good quality seed/brood stock selection, stocking and rearing practices, water quality management, feed management, health monitoring/Biosecurity, disease management, responsible use of treatments and chemicals, better Harvest and post-harvest Practices, Record maintenance/Traceability, environmental awareness and food safety awareness.

There is evidence to show that it is possible to bring change in the behavior, attitude and practice of small farmers by demonstrating cost-benefits of simple/practical farm level biosecurity measures and better management practices. Basic biosecurity audit check-lists can be very easily used for self-assessment of biosecurity risks and gaps for any given facility. The findings can form the basis for decision making on cost-effective biosecurity plans and investments (WorldFish Biosecurity check list: https://hdl.handle.net/20.500.12348/4985). Simple epidemiological tools can be used to gather information from farming systems on behaviour and practice of farmers, production practices, production outcomes, mortality events, socio-economics, etc. Epidemiological analysis of data can help to identify trends, associations and risk factors, which can further inform development of interventions in the form of better management practices and farm level biosecurity plans. (Aquatic Animal Health Package of Practices: Fish epidemiology and health economics: https://hdl.handle.net/20.500.12348/4900). The presentation will provide some examples from the biosecurity project being implemented in Nigeria.

Aquatic animal diseases and one health issues (e.g. AMR) is a product of actions of various actors and elements involved in the food systems and beyond. Collective action under a one health framework is necessary to promote responsible and sustainable aquatic food systems.

By: Charo-Karisa, Harrison
Title: Catalyzing Aquaculture Development through World Bank Group's Aquabusiness Advisory Platform

Aquaculture is one of the pillars of world food systems, with a large potential to contribute to a healthy food and environment systems. It is the fastest growing food production sector worldwide holding considerable potential for sustainable growth of rural economies, food and nutrition security, and employment for youth and women. In 2020, aquaculture produced 112.6 million tonnes, well over 50% of the 214 million tonnes of aquatic foods. The sector engages over 20 million people and often operates on the margins of natural spaces and ecosystems. Most fish, shellfish and aquatic plants production comes from smallholder farms in fresh, brackish and marine waters.

Further development is hampered by poor access to credit, lack of technical know-how, poor access to quality inputs such as genetically improved seed, quality feed, high cost of production, poor infrastructure, and marketing challenges. In the face of increasing Climate Change threats, application of technologies that enhance ecosystem resilience are urgently needed to ensure sustainability. Innovations around improved resource-use efficient systems, application of digital technologies, reduction of greenhouse gas (GHG) emissions from aquaculture, circular economy are emerging and the use of genetically improved quality seed is gaining acceptance globally. The high cost of fish meal and environmental concerns have led to a search for alternative protein sources, including animal and plant-based ingredients.

The World Bank Group (WBG) Aquaculture Agribusiness Investment Advisory Platform is a collaborative initiative funded by the PROBLUE Umbrella Multi-donor Trust Fund that aims at distilling and improving best practices in aquabusiness development for economic, social, and environmental sustainability. Launched in 2022, this platform involves multiple collaborators, including theEnvironment and Natural Resources (ENB), Blue Economy and Agriculture and Food Global Practices (AGF) International Finance Corporation (IFC) at the World Bank. It also collaborates with Food and Agriculture Organization of the United Nations (FAO), Global Environment Facility (GEF), United States Agency for International Development (USAID), and World Wildlife Fund (WWF). Specifically, the Platform informs WBG, development partners, commercial investors, and public-sector on interventions that enhance aquaculture's contributions to the development of the global Blue Economy by improving environmental management, water quality, and the health of communities involved in both freshwater and marine aquaculture development. The Platform offers demand -driven technical assistance to Governments, Country teams and private sector entities through guidelines to aquaculture investment, frameworks for enabling private sector investment, advisory services to private aquaculture investors, carrying capacity studies, and sharing global lessons from advanced aquaculture countries to inform government policy and regulatory frameworks, unlock the sector and attract public and private sector investment.

By: Ene-Obong, H.N.; Tolar-Peterson, T.; Adegoye, G.A.; Nunta, N.J.; Pasqualino, M.M.; Estate, J.; Okere, I.; Akpanuko, A.; Pincus, L.

Title: Improving the Quality and Safety of Processed Fish Products: Building Capacity Approach

Introduction: Malnutrition continues to be a public health problem in Nigeria. Recent figures show that 33.3%, 11.6% and 25. 3% of children 6 -59 months are stunted, wasted and underweight; 62% are anaemic, while 55% of women of reproductive are anaemic (NFCMS, 2022). High rate of stunting is linked with poor cognitive development, lower educational performance, and low productivity in adulthood, consequently contributing to poverty and poor economic development. Many factors contribute to malnutrition in Nigeria, namely, poverty, inadequate dietary intake, infections, food insecurity, ignorance, cultural beliefs, poor governance to mention a few.

Fish can contribution to solving the nutritional problems if adequate harnessed and utilized. It is an important source of essential nutrients: long-chain Omega -3 polyunsaturated fatty acids, high quality and digestible protein, vitamins (A, B, & D) and mineral (iron, calcium, phosphorus, selenium, iodine, and zinc), In Africa, fish is a relatively affordable and accessible animal-source food (ASF) that is important for poor and marginalized women, men, and youth (Belton and Thilsted, 2014; World Fish, 2017). It is the most consumed ASF in Nigeria **(**Byrd et al. 2019) but its consumption is said to be relatively low in Africa and Nigeria. The annual per capita consumption of fish in Nigeria, Africa and globally is 13.5kg, 9.9kg and 20.3kg (WorldFish, 2017; FAO, 2018). Nigeria also relies on fish and fisheries for nutrition and livelihoods because of its many water bodies and access to the sea (FAO, 2018; Selig e al., 2018).

Fish is a highly perishable food and can be contaminated with many harmful substances during production, harvesting, processing, display in the marketplace, and storage. As a result, fish is usually subjected to processing to limit spoilage and losses. Fish contamination can be hazardous to human health. The quality of a food commodity is a combination of several factors, including the sensory attributes (appearance, colour, taste, odour), nutritive value, adulterants, contaminations (microbiological, physical, chemical) and hygiene (conformity to sanitary norms).

Capacity building according to the United Nations can be defined as the process of developing and strengthening the skills and abilities, processes, and resources that organizations and community need to survive, adapt and thrive in a fast-changing world. The FAO/UN also defines capacity building as the process of unlashing, strengthening and maintaining the ability of people, organizations, and society as a whole to manage their affairs successfully. It is therefore necessary to build the capacity of fish handlers and processor so that good quality and safe fish products can in produced and sold to consumers for their well-being.

Objective of the study: The objectives of this study are to: i) Develop cost per nutrient guides by analyzing the nutrient and contaminant profile of select processed fish products and their respective prices in comparison to other ASF available in Delta State, Nigeria; ii) Build capacity among women and youth fish processors in Delta State to produce high quality, safe, and nutritious processed fish products for local consumption; Educate women and youths fish processors in Delta State about the benefit of fish in human diet and develop low-literacy tools to help them better market their product.

Method: The study was done in Delta State Nigeria. Delta State is a USAID Zone of Influence.

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It was selected to leverage the knowledge WorldFish gained from a 2019 scoping study on the fish value chain. Delta State is blessed with abundant inland and coastal waters with rich and diverse fish species. The inhabitants also engage in fishing, fish processing & marketing activities.

Two capacity building training workshops were planned: i) Nutrition & Food Safety (completed); ii) Fish processing, value addition and investment opportunities for fish processors (to be undertaken in November, 2022). The programme picked off with a preliminary visit to establish contact with key stakeholders in the State, followed by a familiarization tour of major fish markets in Delta State. A pre-survey aimed at collecting baseline data and determine the knowledge, attitude and practice of the fish processors was conducted. Low literacy teaching tools and curriculum were developed and validated by experts in the field. Learning cues were also developed in form of fans, aprons, hand bands, etc. The efficiency of the teaching was also tested.

Training: A 5-day each train-the trainer workshop was organized for 122 fish processors in Asaba and Warri, facilitated by the Nourishing Nations research team, the Program Manager and Director of fisheries, Delta State Agricultural & Rural Development Authority (DARDA); Director of Planning, Research and Statistics, Ministry of Agriculture and Natural Resources (MANR); Head, Women in Agriculture, DARDA; Delta State Nutrition Officer from the State Primary Health Care Development Agency; and State Director of Fisheries, MANR. Training covered nutrition and food safety topics, split into seven modules. A post-training evaluation was conducted 6 weeks after the training.

Result: Both the pre-survey data and the number of participants at the training showed that there were more female fish processors (>70%) than males, majority of whom were between 19 and 49 years old; with only 36% completing secondary education. About 93% had no formal training in fish processing and the major processing method employed was the traditional smoking, resulting in poor quality fish products. The working environment and fish handling practices were inadequate. Major challenges expressed by fish processors were poor electricity supply, lack of access to credit and other forms of support; losses because of insect infestation and mold; high cost and lack of technical know-how on the operation of modern kilns and lack of awareness of value-added fish products. The first training addressed nutrition knowledge issues, fish handling practices, including hygiene and sanitation, fish preservation and storage and few theoretical tips on value addition and fish processing. The post training evaluation produced a significant improvement in nutrition knowledge, while behaviour change modification was not significantly different as at the time of evaluation. Overall, participants were excited with the training and eagerly looking forward to the practical training. They gave testimonies of the new things they are now trying to do to improve their business and products.

Conclusion: Fish processing appears to be dominated by women in Delta State. From observation, there are no cooperatives societies for fish processors in the State. Regular training to build their capacity for producing good quality fish products, and forming cooperatives is advocated. It is believed that this will have a multiplier effect as it will improved the livelihood and earnings of the processors and the women will also utilize the improved quality and value-added fish products to feed their families and improve their household nutritional status. The second training will address the issues on fish processing methods and value addition, business development and formation of cooperatives. The Nourishing Nation team will be partnering with the “Cultivating New Frontiers in Agriculture (CNFA) also based in Asaba Delta State, Nigeria to carry out the training.

Partners include: WorldFish, Mississippi State University, and University of Calabar

By: Falaye, Eyiwunmi and Siriwardena, Sunil
Title: Achieving National Goals: Policy and Institutional Bottlenecks

The current organizational structures and regulatory framework at Federal and State level are quite suitable to promote the growth of the aquaculture industry despite the challenges been faced. Administrative, planning and regulatory duties are within the purview of the Federal Department of Fisheries and Aquaculture under the Federal Ministry of Agriculture and Rural Development, and Departments of Fisheries in the States on all matters of fisheries policies, regulation and administration. The other federal and state level institutions have influence on aquaculture development are Federal Ministry of Land, Housing and Urban Development, Sate Ministry of Lands and Surveys, Federal Ministry of Water Resources, Sate Water Agencies, Federal Ministry of Environment, State Ministry of Environment, National Environmental Standards and Regulation Enforcement Agency, State Environment Protection Agency, Federal Ministry of labour and Employment, and Federal Ministry of Industries, Trade and Investment.

Acts governing the aquaculture sector are the Fisheries Act of the Federal Republic of Nigeria (2014) and the Inland Fisheries-Aquaculture Regulations (2017). The Inland Fisheries (Aquaculture) Regulations empowered the Federal Department of Fisheries and Aquaculture as the competent authority to implement the regulation. Detailed requirements and explanations are given in the Inland Fisheries Act on the official control programmes (for value chain activities) in order to conform to good aquaculture practices and international standards for traceability and certification. Registration and approval programme for Fish Farm is clearly spelt out in Part II of the Inland Fisheries (Aquaculture) Regulations as well as environmental guidelines and assessments, aquatic animal health regulations, waste disposal and pollution control, standards and food safety; and sanitary and phytosanitary controls.

There is no dedicated policy for fisheries and aquaculture development in Nigeria. Elements in several policies have influenced on the fisheries and aquaculture sector. The most recent (within the past decade) policy and development strategies and plans influencing fisheries and aquaculture sector consist of following documents: a) Nigerian Vision 2020; The Agricultural Transformation Agenda (ATA) – 2011; The Agriculture Promotion Policy (APP) -2016; The National Aquaculture Development Plan – 2011; National Water Policy 2016; Land Use Policy, 2004; Nigeria Public Private Partnership Policy, 2016; and National Policy on the Environment, 2016.

The notable institutional and policy gaps are discussed in the presentation. In conclusion, given the importance of fish value chain in Nigerian lives and its power on reducing poverty and influence on the overall growth of agri-food systems, fish value chain deserves a dedicated policy for growth.

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By: Fregene, Bernadette
Title: Disseminating Technologies for Smallholder Aquaculture: TAAT Experience

The Technologies for African Agricultural Transformation (TAAT) program, funded by the African Development Bank (AfDB), is a knowledge- and innovation-based response to the need to scale up proven technologies across Africa. It aims to boost productivity and make Africa self-sufficient in key commodities and the program is being implemented in 31 countries. The overall goal of TAAT is to execute a bold plan to achieve rapid agricultural transformation across Africa through raising agricultural productivity along nine priority commodity agricultural value chains (maize, wheat, rice, sorghum/millet, cassava, high-iron bean, orange flesh sweet potato, aquaculture and small livestock) with the support of enablers. Since 2018, TAAT has delivered proven agricultural technologies to the Bank's Regional Membership Countries (RMCs) as a means of achieving Agricultural Transformation.

Aquaculture Compact, is one of the nine commodity compacts and is led by WorldFish. It aims to increase African aquaculture production by sustainable intensification of existing aquaculture enterprises through building resilient small and medium enterprises (SMEs) and large-scale aquaculture businesses in twelve countries Central (Burundi, Cameroon, DR Congo), Eastern (Kenya and Tanzania), Southern (Malawi and Zambia) and Western (Benin, *Côte* d'*Ivoire*, Ghana, Nigeria and Togo) Regions of Africa.

Thirteen proven aquaculture technologies in 12 countries were deployed to the Aquaculture Value Chain Actors (AVCAs). The National Agricultural Research and Extension Systems (NARES) and private sector actors were trained as trainers for deployment of fish seeds and feed production, fish value addition and Better Management Practices (BMPs) technologies in the implementation countries. Rearing systems including hapa system for mass production of fish seeds project, In-Pond Race Way System (IPRS), cage-based and pond-based aquaculture systems were also deployed. Aquaculture Compact partnered with NARES through: (i) Outreaches (ii) technology and innovation dissemination (iii) capacity building; and (iv) efficient management. Aquaculture technologies and innovations were disseminated and scaled out through the private sectors and Innovation Platforms (IPs) of the participating countries.

Fish breeders were supported with 10,000 improved brood stock for fingerlings production. Over 177 million fingerlings were produced for dissemination to SMEs in the established 92 demonstration centers. More than 23,000 AVCAs have been impacted through capacity building, mass production of mono sex tilapia and catfish fingerlings in hapas for increased survival rate of 90%. Quality low-cost fish feed production using locally available raw materials reduced production cost by 30% when compared to the use of only imported fish feed. The use of improved solar tent driers and smoking kilns adopted by fish processors reduced their exposure to direct fire and produced high quality sand-free value-added fish products. Three Extension Manuals were published, training modules designed and published; and five TAAT Aquaculture Compact videos were also produced.

In conclusion, self-sufficiency in fish production is required to feed Africa. Therefore, proven aquaculture technologies must be deployed for adoption and scaling. It is important to strengthen skills of AVCAs in fish seed and feed production, fish processing, BMPs, marketing, and business development. There is a need to advocate for countries to take loans for adoption and scaling of

aquaculture technologies to be self-sufficient in fish production because grants are limited. Private-Public-Partnership should be encouraged for technology scaling since aquaculture is private sector driven.

By: Isa, Suleiman
Title: Catfish (*Clarias gariepinus*) Genetics and Improving Catfish Hatchery and Seed Supply

The African catfish *Clarias gariepinus* is increasingly becoming an important aquaculture candidate in the sub-Saharan Africa, the most important species in Nigeria and an efficient feed converter, thus, its culture spans 4 continents of the world despite being native to Africa. This growth of the catfish industry in Nigeria is limited by inadequate supply of good quality fish seeds (fingerlings and juveniles) and good quality fish feeds.

For any meaningful genetic improvement to occur in any species, understanding the anatomy, taxonomy and physiology of the species is important. The African catfish, *C. gariepinus* is still not easily distinguishable from other members of its genus and sub-genus. Several studies using chromosome number, allozymes, mitochondrial DNA (cytochrome-b) were conducted to enable separation between *C. gariepinus* and its closest relative, *C. anguillaris*, which occurs sympatrically in the wild. These studies identified private alleles; however, they were not consistent and non-diagnostic. In a more recent studies, next generation sequencing specifically double digest restricted site associated DNA sequencing (ddRADSeq) was used to develop the first ever diagnostic sets of markers clearly separating *C. gariepinus* from *C. anguillaris* (S. Isa, et *al*. 2019). Over 2,500 SNP markers were generated and used to produce a phylogeny of the two putative species and an out-group (*H. longifilis*), and a principal component analyses of this dataset clearly separated these two species and the out-group from one another. All members of the Dutch domesticated strain of *C. gariepinus* from three farms in Nigeria, three farms in The Netherlands, a source of the Hungarian and Polish strains, all shared the same genotype as the wild *C. gariepinus* from Rivers Niger and Benue, and stocks from Egypt (the WorldFish center) and Zambia.

In a separate study on hatchery practices in the *C. gariepinus* catfish industry, it was gathered that only 3% of farmer exclusively sourced broodstock from the wild, 54% of the respondent dealt only on *Clarias gariepinus*, and 46% produced *C. gariepinus, Heterobranchus longifilis, Heterobranchus bidorsalis*, and their respective hybrids with *C. gariepinus*. By implication, when a breeding programme is planned, attention needs to be paid the species produced by the hatcheries, why, and how a multispecies hatchery will perform against a mono-species hatchery. With 95% of respondents reusing their female broodstock, 67.57% of them reuse them up to three times in a year and only 3% of the respondents maintain a mating ratio of 1:1, the effective breeding number (Ne) will rapidly decrease in an already inbred stock. This is further exacerbated by the fact that 94% of hatcheries select broodstock at grow-out stage, which are likely to be bred from a single mom and dad in commercial hatcheries. It is therefore important that the best management be adopted by every hatchery operator.

To understand the levels of inbreeding and genetic variation within and between farms, 282 fin samples were collected from broodstock of *C. gariepinus* in 35 locations (33 hatcheries and Rivers Niger and Benue). Next generation sequencing (DArTSeq) was used to develop SNP chips. From the results, 72,140 loci were identified from 280 samples (the remaining 2 samples failed). Following filtration, 6,797 loci and 276 individuals were called. An average observed heterozygosity of 0.082034 and an expected heterozygosity of 0.091318 were recorded. The very low heterozygosity values suggest that most of the farmed populations are inbred. It is noteworthy that 12 of the 33 farmed populations had negative F_{IS} values, suggesting no inbreeding within the populations sampled.

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The above studies have laid a solid foundation upon which any planned genetics improvement programme can be based.

By: Nurudeen, Lasisi

Title: Bridging the Demand and Supply Gap of Affordable Commercial Feed in Nigeria

Feeding cost has accounted for 70-85% of production cost in Livestock, Poultry and Aquaculture productions. Hence, it is essential that such feed must be of premium quality (efficient in digestibility, assimilation and utilization) in other to justify for it's worth.

Inadequate supplies or lack of access to such quality feed is a major problem in Nigeria and most Sub-Saharan African countries. This presentation looks into the hinderances, challenges and factors affecting supplies of commercial feeds and also suggested and recommend solutions to overcome future occurrences.

By: Oke-Tojinu, Sejiro Michael / Catfish Farmers Association of Nigeria (CAFAN)

Title: Diversification of farming systems and species in Nigerian aquaculture: Catfish farmer association perspective

The aquaculture industry in Nigeria has the potential to generate more revenue than the oil and gas sector if the adequate attention is given at all levels of production by the government, international agencies and relevant stakeholders.

However, beyond her growth in the catfish industry and rating as the biggest producer of catfish fish in Africa, Nigeria needs to improve on a lot more in order to make aquaculture better lucrative and sustainable. The fish farmers yearn for diversification into more species other than the catfish and tilapia.

Post-COVID, the fish farmers are battling with loads of challenges to remain in the business despite doing so much to improve production.

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By: Oludayo, Ganiyu
Title: Diversification of Species in Nigerian Aquaculture: A Farmer's Experience

Fish farming is considered an important agricultural activity that is capable of ending nutritional deficiencies of the world and contributing to poverty reduction. Fish is an important part of the household diet in Nigeria, which is the most populous country in Africa. Fish accounts for around 40 percent of the country's protein intake, with fish consumption at 13.3 kg/person/per year. Nigeria is the largest fish consumer in Africa and among the largest fish consumers in the world with about 3.6 million metric tons of fish consumed. The aquaculture sub-sector is considered a very viable alternative to meeting the nation's need for self-sufficiency in fish production. This is based on its high reliability in return on investment and low capital intensity relative to capture fisheries. The aquaculture industries in Nigeria is very promising, as there is presence of water bodies and high demand for fish among others.

About 80% of fish farmers in Nigeria engage in catfish farming and it is the commonest type of fish used in aquaculture in Nigeria.

Nigeria's annual fish demand is 3.6 million metric tonnes, but only able to produce only 1.2 million metric tonnes through the artisanal, industrial and aquaculture. The deficit is being supplemented by frozen fish importation, which is being used to bridge the gap costing it about 1.2 billion USD annually which deplets Nigeria's forex.

Some of the domesticated fish imported and sold as frozen have been cultured and they have thrived well in Nigeria with 95-98% survival rate, acceptance in the market, low cost of production and they can be farmed under monoculture and polyculture systems. Some of these breeds include: Pangasius, Freshwater Brama, common carp, Rohu. Leveraging on these breeds can help in meeting up with the future supply and demand as catfish alone cannot help us to meet up with that. These breeds have much prospects in helping fish farmers, giving food security in the country and exportation for the growth of Nigeria economy. So, diversification is the answer!

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By: Reichley, Stephen and Lawrence, Mark
Title: Overview of the Feed the Future Innovation Lab for Fish

The Feed the Future Innovation Lab for Fish, funded by the U.S. Agency for International Development (USAID), aims to reduce poverty and improve nutrition, food security, and livelihoods in developing countries by supporting the sustainable development of aquaculture and fisheries systems.

The Fish Innovation Lab is one of 20+ Feed the Future Innovation Labs leveraging the expertise of U.S. universities and developing country research institutions to tackle some of the world's greatest challenges in agriculture and food security. These labs harness U.S. and global expertise on a variety of food security topics – from horticulture to food security policy and beyond.

The Fish Innovation Lab focuses on applied reach in Bangladesh, Cambodia, Ghana, Kenya, Madagascar, Nigeria, the Pacific Islands, Peru, the Philippines, and Zambia and has 24 activities, 19 of which are currently active. The lab's program areas include improving productivity, mitigating risk, and improving human outcomes. Additionally, the Fish Innovation Lab has four cross-cutting themes, which are incorporated into each funded project and guide the lab's work overall. These are mainstreaming gender equity and youth inclusion, advancing human and institutional capacity development, strengthening resilience, and advancing nutrition. All the while, the lab's theory of change helps guide the activities to meet these important objectives.

One of the Fish Innovation Lab's key goals is to assess nutrition as both outcome and determinant and support research to identify interventions that optimize human health and livelihoods while sustaining aquatic ecosystems over the long term. Through research in our three areas of inquiry, we delineate and ultimately impact multiple pathways to food security and human nutrition in vulnerable groups living in low-resource households and among smallholder fisher families. It is critical to support pregnant and lactating women, infants and young children, and school-aged children with research that aims at reducing hunger and improving nutrition to decrease childhood stunting and wasting.

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By: Shelley, Colin
Title: Investment framework for Nigerian Aquaculture[1]

An investment framework for Nigerian Aquaculture has been developed to encourage the further growth of the sector to meet the challenges of a rapidly growing population and an increasing demand for protein. It is a roadmap, hopefully catalytic in nature, identifying potential investment opportunities for the private sector, donor and Government communities.

The framework has been developed to address some of the bottlenecks, previously identified in the Nigerian Fish Futures (2021) report.

The Nigerian aquaculture sector is particularly attractive to investors. There are opportunities to replace imports with locally grown fish, a rapidly growing population (huge local market), a projected demand of an additional 750,000t of fish by 2030, just to maintain current consumption rates and a Government trying to reduce the importation of fish.

To transform the sector, solutions are required to address the need for quality inputs (seed & feed), technology, disease management and improved access to capital. Farm clusters and cooperatives, a feature of Nigerian aquaculture, have excellent opportunities to be organised into more commercially oriented enterprises. The expansion of tilapia and catfish farming will require expansion of multiplier hatchery and hatchery sectors respectively. Production of feeds to produce an additional 1 million tonnes required to meet projected industry growth by 2030 will require expansion of both small scale (local) and larger mills. To underpin the massive growth in production anticipated, fish health services will need to be resourced, modern production technology utilised, power supply enhanced and value chains upgraded.

For investors challenges include deal sizes, uncertainty of input costs, political and currency risks.

There is a wide spectrum of investment opportunities available to support the growth and maturation of the Nigerian Aquaculture sector. A range of successful interventions used elsewhere in the globe e.g. BankAsia Fish Card & eFishery, can likely be adapted or emulated by the Nigerian Aquaculture sector to meet some of its challenges.

[1] *The full title of the report, soon to be available on the WorldFish website, is "Nigerian Aquaculture: An investment framework for improved incomes, new jobs, enhanced nutritional outcomes and positive economic returns"*

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By: Steensma, Joe
Title: Adapting a Lean Production Systems Approach to Aquaculture in Nigeria: Save Time, Money, and Grow Your Profits With Lean Aquaculture

"Lean Management Systems" (or simply "Lean") is a widely used business operating system that has transformed operations across sectors and all around the world. Fundamentally, Lean focuses on maximizing productivity while simultaneously minimizing waste in operations. This simple, yet incredibly effective, methodology has been demonstrated to quickly boost production and reduce costs. A further benefit of Lean is that it has easily deployed and adopted in numerous industries, , yet it has not been widely adopted in aquaculture generally, and prior to this project there had not been documented use of Lean anywhere in Nigeria. Given the ubiquity of Lean and its well-documented impact in all other sectors, gaining an understanding of the effectiveness and deployability of Lean in the Nigerian aquaculture sector is important. This project has four major objectives: (1) to rapidly train local aquaculturist in Lean Production Systems in order to develop local expertise (these local experts are called Lean Subject Matter Experts, or LSMEs) (2) through LSMEs bring Lean principles to the broader aquaculture communities in Ogun and Delta states (3) implement process improvement projects (using Lean tools and guided by LSMEs) on farms in participating communities and (4) assess the efficacy and impact of process improvement projects. **Preliminary Results:** Forty LSMEs have been trained (20 in Ogun and 20 Delta), who further disseminated Lean training to over 400 aquaculturists (Ogun n=242; Delta n=181). Participants have implemented 212 Lean process improvements at 175 farms. Many improvement projects resulted in impacts across more than one area of production. Farmers have documented process improvements over 400 times as a result of the 212 projects. Primary areas of focus for Lean projects are (1) reduction in excessive motion (n=58) (2) reduced fuel (n=47) (3) reduce fish mortality (n=41) and (4) reduce cost and time of feeding (n=30). Examples of areas of production that have experienced the greatest improvement as a result of Lean process improvement projects are (1) reduction in mortality (mean improvement = 71%) (2) reduction in extra processing (mean improvement =68%) (3) reduction in medicine used (mean improvement = 73%). **Preliminary Conclusions:** It is essential to note that data collection and auditing of farmer-reported projects is ongoing, but preliminary results suggest Lean aquaculture systems can be successfully deployed in the Nigerian aquaculture sector and local expertise can be developed in order to disseminate Lean principles and technologies.

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By: Subasinghe, Rohana
Title: Global Aquaculture: Where is Nigeria?

According to FAO, total fisheries, and aquaculture production in 2020 was 214 million tonnes, which comprised 178 million tonnes of aquatic animals and 36 million tonnes of algae (seaweed). The global aquaculture production in 2020 reached 122.6 million tonnes, which included 87.5 million tonnes of aquatic animals worth USD 264.8 billion and 35.1 million tonnes of algae (seaweed) worth USD 16.5 billion. Around 54.4 million tonnes were farmed in inland waters and 68.1 million tonnes came from marine and coastal aquaculture. Fisheries and aquaculture sector employs about 58.5 million people in primary production as full-time or part- time workers. Some 35 percent were employed in aquaculture. Interestingly, in 2020, 84 percent of all fishers and fish farmers were in Asia. Overall, women accounted for 21 percent of those engaged in the primary sector. Aquaculture has great potential to feed and nourish the world's growing population. But the growth must be sustainable.

Global consumption of aquatic foods (excluding algae) increased significantly during the last six decades. The annual per capita consumption reached a record high of 20.5 kg in 2019. FAO claims that all regions, except Africa, experienced continued aquaculture growth in 2020. However, Africa experienced a decrease in the two major producing countries, Egypt, and Nigeria, while the rest of Africa enjoyed 14.5 percent growth from 2019, while it slightly declined to 20.2 kg in 2020, owing to COVID-19 pandemic. Rising incomes and urbanization, improvements in post-harvest practices, and changes in dietary trends are projected to drive 15% increase in aquatic food consumption, to supply on average 21.4 kg per capita in 2030.

FAO fisheries and aquaculture projections to 2030 point to an increase in production, consumption, and trade, albeit at slower growth rates. Total production of aquatic animals is expected to reach 202 million tonnes in 2030, with the main increase coming from aquaculture, contributing 106 million tonnes in 2030. Ninety percent of all aquatic animal production will be for human consumption, an overall increase of 15 percent compared with 2020. This means annual per capita consumption will increase from 20.2 kg in 2020 to 21.4 kg in 2030. Aquatic food supply will increase in all regions, while per capita consumption is expected to decline slightly in Africa, raising concerns in terms of food security.

As its population increases from 196 million in 2018 to 263 million in 2030, under Business-as-Usual scenario, Nigeria would need 752 thousand tonnes more fish to maintain 11.2 kg of per capita fish consumption and would need 3.14 million tonnes more fish to reach 20.3 kg global per capita fish consumption, by 2030. Nigeria faces many challenges for expanding and improving the aquaculture sector to improve productivity to meet the demand. This workshop will discuss various aspects, challenges, and opportunities for improving the Nigerian aquaculture sector in the coming decades.

By: Trọng, Trịnh Quốc
Title: Tilapia genetics: Worldfish research and future vision

Tilapias comprise one of the most important group of aquaculture species. Of these, Nile tilapia (*Oreochromis niloticus*) has a world production, both inland and coastal aquaculture, of more than 4.5 million tonnes accounting for 10.3% of total production of major aquaculture species (FAO, 2022). WorldFish has demonstrated that selective breeding is a feasible, cost-effective and sustainable approach to the genetic improvement of tilapia. At WorldFish, Nile tilapia (*Oreochromis niloticus*) of the Genetically Improved Farmed Tilapia (GIFT) strain has a 28-year of selective breeding with 23 generation and being used by 17 governments around the world. Faster GIFT growth rate allows shorter growing season and higher production on the same production area which reduces cost and increases profit. A more resilience GIFT allows production feasible in unfavourable environments and reduce risks of diseases. More recently the organization has commenced selecting GIFT for resilience against pathogens including tilapia lake virus, for improved feed conversion efficiency and better growth under low oxygen conditions, using DNA-based approaches and genomic tools. Today tilapia is the second most cultured fish species in the world and WorldFish is committed to making improved, faster growing and resilient GIFT seed available to farmers to reduce poverty and hunger. The target species include, apart from Nile tilapia, other species in the African continent such as the *Oreochromis andersonii* and *Oreochromis shiranus*.

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GLOBAL CENTER FOR AQUATIC HEALTH AND FOOD SECURITY

By Ugwu, Cyril
Title: Financing Smallholder Aquaculture in Nigeria

Small-scale farmers produce about 70% of the 1million metric tonnes of the fish produced in Nigeria annually. These farmers face myriads of constraints ranging from high cost of inputs, low technical knowledge on modern agricultural technology, lack of improved seed, unorganized market, poor linkage to premium market, poor infrastructure and lack of access to finance. While all these issues have great impact on the performance of the sector in Nigerian economy, access to finance stood out as a major factor to accessing quality inputs, scaling production and achieving competitiveness. Generally, the agricultural sector of Nigeria has huge potentials in transforming the nation's economy but agricultural credit to the sector has been the lowest in past years. When compared to other industries and sectors, agriculture received the lowest credit allocation from banks despite the sector's larger contribution to GDP than other industries. Agricultural credit by Nigerian banks represents between 3 to 5% of total credit to the private sector. Reasons behind this include the obvious perception of risks in lending and high costs of service delivery as major barriers to extending finance to smallholders and agribusiness SMEs. Others include strict collateral requirements, lack of knowledge (on the part of the banks) on lending to SMEs in agriculture and farmers, foreign exchange and price volatility since hedging mechanisms are not commonly available. These make it difficult and most times impossible for agribusiness SMEs to fund operations that involved smallholders. The total demand for agricultural finance in Nigeria is estimated at ₦83 trillion ($200 billion) while available supply is just about ₦7trillion giving a gap of about 91% gap in agricultural finance in Nigeria.

Financing smallholder farmers in aquaculture in Nigeria will require a blended approach with the aim of providing affordable credit to farmers and other agribusiness SMEs in the aquaculture sector in Nigeria. Funding in the sector is needed for sourcing quality input, working capital, and capital asset acquisition among others. IDH has developed a value chain financing model for smallholder financing in Nigeria. The model is inclusive, sustainable, and commercial with required risk mitigation measures. The model posits that a blend of market, partnership, innovation, and investment into the aquaculture sector will produce quality food, profit, jobs, and growth in GDP of the nation and lead to the preservation of the planet.

Injecting adequate finance into the aquaculture sector in Nigeria will enhances competitiveness, improve financial inclusion in the agricultural sector, boosts sustainable production, enhance farmers income and improvement of livelihoods and creates opportunities for innovative financing solutions.

About IDH:
IDH is a Dutch Foundation with mandate for inclusive development through market transformation. IDH puts people, planet and progress at the heart of trade by leveraging the power of markets to create better jobs, better income, better environment, and gender equity for all. We work with people within corporations, the global financial sector, and governments on inclusive and sustainable solutions to transform value chains. Funded by Dutch, Swiss, Danish and Norwegian governments, IDH core areas include convening that creates an open, solution-oriented environment, co-financing and co-creation of roadmaps that can help organizations at any point in their sustainability journey and learning and Insights. IDH works on 12 sector programs, 20 Landscapes, in 40 countries and with about 1000 private, government and non-governmental organizations.

By: Umoh, Ime

Title: National Vision for Aquaculture Development in Nigeria

Nigeria, with a potential of aquaculture production of about 2.66 million metric tonnes annually produces currently about 313, 231 metric tonnes with a national deficit of about 2.5 million metric tonnes and extremely high foreign exchange bill on frozen fish importation, Nigeria has to vigorously pursue research and development in aquaculture to bridge the wide gap between fish demand and supply; for purpose of sustainable food and nutrition security, job creation, poverty alleviation, import reduction and possibly foreign exchange accessibility.

For over a decade now, Nigeria aquaculture system and practice have been dominated by the culture of the African catfish *Clarias gariepinus* through the use of homestead fish farming, earthen and concrete ponds, reinforced fibre glass tanks, collapsible tanks and currently small scale and commercial fish cage culture farming.

Nigeria is working assiduously to increase domestic fish production through improvement in fish farming practices necessitated by prevailing declining catch from capture fisheries as a result of overfishing, low upwelling, shallow continental shelf, negative impact of climate change, water body pollution, over-exploitation and IUU (Irregular, Unreported and Unregulated) fishing.

The country is at the verge of collaborating with relevant research institutes on the culture of indigenous fish species in a view to diversifying our cultivable species and create choice preference for consumers. The Government is also in collaboration with some foreign partners such as WorldFish as regards to the cultivation of some exotic genetically improved species (Genetically Improved Farmed Tilapia) in the country.

On the issue of data integrity the Department has adopted reliable, cost effective, ICT solution in tackling this issue, the process for its implementation has scaled the NCARD (National Council on Agriculture and Rural Development) defense process and we are hoping that it goes into the next budget for implementation.

Nigeria Fisheries and Aquaculture programmes, projects and activities are geared towards the actualization of the aforementioned constraints as contained in the National Aquaculture Strategy document for Nigeria. These measures includes promoting small scale and commercial cage culture system, Certification and Standardization of aquaculture farms and facilities, diversification of indigenous cultivable fish species and promotion of fish farm clusters across Nigeria for increased fish production, poverty reduction and other attendant benefits.

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