Aquaculture Stakeholders and Antimicrobial Stewardship Network

Stakeholder Report

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Abbreviations

ACDC	Africa Centre for Disease Control
AM	Antimicrobial
AMR	Antimicrobial Resistance
AMU	Antimicrobial Use
AMS	Antimicrobial Stewardship
AST	Anti-sensitivity Testing
AU	African Union
AU-IBAR	African Union Interafrican Bureau of Animal Resources
COP	Codes of Practice
ECOWAS	Economic Community of West African STates
FAO	Food and Agriculture Organisation of the United Nations
FISON	Fisheries Society of Nigeria
FMARD	Federal Ministry of Agriculture and Rural Development
FME	Federal Ministry of Environment
FMH	Federal Ministry of Health
GAP	Global Action Plan on Antimicrobial Resistance
GLASS	Global Antimicrobial Resistance Surveillance System
LIMS	Laboratory Information Management Sysems
LMS	Livestock Management Services
NAP	National Action Plan for Antimicrobial Resistance (2017-2022)
NAFDAC	National Agency for Food and Drug Administration and Control
NAS	Nigeria National Aquaculture Strategy
NCDC	Nigeria Centre for Disease Control
NVRI	National Veterinary Research Institute
NVMA	Nigerian Veterinary Medical Association
PEA	Political Economic Analysis
PPP	Public-Private Sector Partnership
RM	Residual monitoring
SOPs	Standard Operating Procedures
SDGs	Sustainable Development Goals
WHO	World Health Organisation of the United Nations

EXECUTIVE SUMMARY

The rising prevalence of antimicrobial resistance (AMR) in Nigeria, as it is globally, is having negative impacts for human and animal health due to the reduced efficacy of treatments. Prolonged illness, increased treatment costs and mortality are among the negative impacts that make AMR a threat for public health and food-safety. Animal food value chains and the environment have become major pathways for the spread of AMR to humans because the same antimicrobials are used to treat animals and humans, and residues of these find their way into the environment. Global initiatives to address AMR have consequently adopted the One Health approach to prevent and contain the spread of AMR within and across the human-animal-environmental interface.

AMR within Nigeria's aquaculture sector also cuts across the human-animal-environment interface. The findings from the aquaculture AMR Situation Analysis which informed this stakeholder analysis, reaffirmed the status quo. The risk determinants for AMR in Nigerian aquaculture were found to be multifaceted and influenced by multiple stakeholders from the One Health sectors and the public and private sector domains. The need for creating awareness on aquaculture AMR in order to change stakeholder's attitudes and promote their participation in antimicrobial stewardship was evident.

An initial understanding of who the sectors stakeholders were and their roles in aquaculture AMR was required to assess what opportunities existed for mobilizing them to act coherently to limit the use of veterinary medicines and safeguard against AMR. The most feasible approach was found to be one that addressed stakeholder needs for aquatic animal health and welfare, biosecurity control and aquatic environmental health because antimicrobials use in the aquaculture value-chain was largely driven by the economic losses that arose from incidences fish disease and mortality in aquaculture facilities.

The formation of an aquaculture stakeholder antimicrobial stewardship network as a forum through which public and private aquaculture sector actors could network and coordinate actions for the control aquatic animal disease and AMU/AMR control was consequently recommended. Among the expected outcomes of this action is the generation and sharing of evidence based information, development and adoption of sector best practices, improved public awareness and advocacy against AMR to foster collaborative linkages among stakeholders and facilitate antimicrobial stewardship in the aquaculture sector.

MAIN REPORT

1.0. Background and Introduction

Antimicrobials are among the most useful therapeutic agents used in human and animal health. The presence of antimicrobial residues in food products and the environment have resulted in the selection of antimicrobial resistance genes and resistant microbes. Selection and resistance are exacerbated in production systems and localities where there is overuse and/or misuse of antimicrobials. As a result, animal food value chains and the environment have increasingly become both pools and pathways for the spread of antimicrobial residues, antimicrobial resistance genes and resistant pathogens from animal products to humans[4,5,6]. This spread reduces the efficacy of antimicrobials in humans and livestock, prolongs illness, increases treatment costs and mortality. Antimicrobial Resistance (AMR) has rapidly evolved into a global public health and food-safety risk.

To address this concern, a global framework, the Global Action Plan on Antimicrobial Resistance (GAP), has been developed to slow and contain the development of AMR[18]. The GAP takes into cognizance the Sustainable Development Goals (SDGs) and the intricately intertwined AMR entry points, hotspots, and pathways existing within and between the human-animal-environmental health sectors. To sustain the effectiveness of antimicrobials, the GAP aims to ensure access to safe and quality-assured medicines by those who need them, responsible use of antimicrobials, and minimizing the transfer of resistant genes across the human-animal-environment interfaces. The recommendations of the GAP integrate the concepts of One health. A Global Antimicrobial Resistance Surveillance System (GLASS) has also been put in place to monitor the implementation status and outcomes of the GAP[19].

Following the recommendations of the GAP, the Nigeria Centre for Disease Control (NCDC) undertook a national AMR situation analysis in 2017[13]. The findings and recommendations of the situation analysis were articulated into the country's National Action Plan for Antimicrobial Resistance (2017-2022) (NAP)[14]. According to the NAP, the scope and extent of AMR in Nigeria was broad and highly prevalent in humans, livestock, aquaculture, and the environment. AMR in Humans and animals were found to be caused by similar microorganisms and treated with similar antibiotics. The bottlenecks affecting the delivery of human health and veterinary services (poverty, poor human and animal nutrition, poor sanitation, and low public awareness), were also key factors that determined antimicrobial use (AMU) practice, even in situations where official guidelines and regulations existed.

Considering the complexity and multisectoral facets of these challenges, the NAP like the GAP adopts the one health approach to prevent and reduce the evolution of antimicrobial-resistant organisms and their impacts on health care. The major objectives of the NAP are to:

(i) Increase awareness and knowledge of AMR and related topics
(ii) Establish a 'One health' AMR surveillance system that contributes to the GLASS
(iii) Intensify infection prevention and control in all health sectors
(iv) Promote rational access to antibiotics and antimicrobial stewardship
(v) Invest in AMR research and development[14].

1.1. Aquaculture Antimicrobial Use and Resistance Situation Analysis

To establish a population-based one-health aquaculture AMR surveillance system that integrates with the national One Health AMR surveillance system, an aquaculture Political Economic Analysis (PEA) framework was developed (appendix 1). The aquaculture PEA integrated the One Health approach and took into account the objectives of the NAP, Nigeria National Aquaculture Strategy (NAS), and international guidelines for the control of AMU/AMR in aquaculture production, aquatic animal health, and animal foods [4,5,6,7,14,]. The aquaculture PEA additionally sought to identify which socio-political and economic factors acted as drivers for AMU in Nigeria's aquaculture industry and assess how best resources within these two domains could be harnessed for the establishment and sustainability of aquaculture AMR surveillance.

A country and sector situation analysis was subsequently conducted as a first step in the aquaculture PEA to ascertain the status of aquaculture AMU/AMR within the country and aquaculture value-chain. The situation analysis identified among others, the policy and institutional setup of the aquaculture sector, stakeholders, AMU practices, and AMU/AMR drivers and control opportunities. The findings of the situation analysis revealed the indiscriminate use of antimicrobials in the aquaculture sector. The extra-label use of drugs and use of antibiotics indicated only for human or livestock use were commonly used by fish farmers for prophylaxis and treatment against fish diseases. The by-products of poultry and livestock production were directly used to feed or fertilize fish ponds even when these farm animals were still under treatment. The drivers for AMU were found to be largely economic as producers and traders sought to maximize productivity and returns. AMU was also common practice at the post-harvest end of the aquaculture value-chain especially including where live fish was destined for human consumption. Indiscriminate AMU was found to be further exacerbated by the limited access to veterinary services, animal diagnostic laboratory services, and extension services. The low levels of awareness on aquaculture AMR by the sectors stakeholders including the meida was another bottleneck hindering the promotion of aquaculture AMR control and stewardship.

The aquculture AMR county situation analysis also found that fish and livestock farmers directly disposed of unused antimicrobials and products into drainage, bushes or rivers around farms. Water containing improperly disposed of antimicrobials or antimicrobial residues entered fish farms as run-off during the rainy season or through the water source for fish farms that were located downstream. The entry points, pathways, and potential hot spots for AMU/AMR into and from the aquaculture value chain were, thus found to be via water sources, fish feeds, fish products and the environment.

1.2. Antimicrobial Stewardship

The findings from the aquaculture AMR country situation analysis concurred with findings from studies reported in literature to assess the impact of aquaculture practices on the development and spread of AMR through the food chain and the environment [1,11,12,15,16,17,21]. The findings of the aquaculture AMR country situation analysis indicated that the risk determinants for AMU and AMR in Nigerian aquaculture were multifaceted, cut across all health sectors and were influenced by multiple stakeholders from the private and public sectors. The findings reaffirmed the recommendations of the NAP and assumptions of the aquaculture PEA framework on the need for fostering the participation and contribution of all the sectors stakeholders in antimicrobial stewardship.

Antimicrobial stewardship (AMS) is defined as coherent set of actions that promote the proper use of antimicrobials to ensure sustained access to effective therapy for all who need it[3]. These actions seek

to influence stakeholder behavior towards the prudent and judicious use of antimicrobials. The success of any developmental intervention depends not only on the relevance of the intervention but, more importantly, on the extent to which the beneficiaries and the wider community can accept, value and contribute towards the implementation of that intervention. The synergy with which the different stakeholders execute their roles and responsibilities is a critical factor. Different stakeholders will have different interests and roles to play in antimicrobial stewardship. In aquaculture, AMU and the likelihood of AMR are influenced by the different behavior, interests, and roles of the sectors multiple stakeholders, namely; farmers, veterinarians, fish processors, fish traders, extension workers, input suppliers, diagnostic laboratories, policymakers, neighboring farmers, and communities. The effectiveness of any aquaculture AMS intiative in this case, will e depend on how effectively stakeholders' actions can be integrated and anchored into the sector, the application of One Health policies to aquaculture, and the capacity of public and private sector aquaculture institution to implement and sustain AMS. A multistakeholder forum where stakeholders can interact, coordinate actions, establish functional linkages and share experiences therefore becomes essential for promoting and implementing One Health antimicrobial stewardship in aquaculture.

2.0. Objectives of the Aquaculture Stakeholder Analysis

The objective of the in-depth aquaculture stakeholder analysis was to determine how best aquaculture sector stakeholders could be mobilised to participate and contribute towards antimicrobial stewardship and AMR surveillance in the sector.

The specific objectives were to:

(a) map the stakeholders of the aquaculture value chain while elaborating their specific roles in aquaculture AMU/AMR.
(b) understand the factors that influence stakeholder behavior and determine each stakeholder's level of control over aquaculture AMU/AMR.
(c) establish what antimicrobial stewardship and related behavioral changes would expected from each stakeholder
(d) generate recommendations for establishing an aquaculture stewardship network.

3.0. Methodology

Multiple tools were used to generate the data and information used for the stakeholder analysis:

(a) *Literature Review* – Stakeholder groups and roles were initially identified based upon literature review. This was augmented by in-country direct and phone consultations to verify these stakeholders, identify those currently active within the sector and obtain their contact details. The latter was done by the Fleming Fund project coordinating unit led by Livestock Management Services (LMS)/DAI.

(b) *Online stakeholder consultative meetings* – Stakeholders from both the private and public sector contacted above, were subsequently invited to participate in online meetings. During the meetings, they further elaborated on their roles and responsibilities and on how they worked with each other. In addition, they identified other key stakeholders that

played important roles in aquaculture AMU/AMR. These were recommended for key informant interviews (Appendix 2).

(c) *Establishing stakeholder roles* - Given the objectives of this stakeholder analysis, primary stakeholders were considered to be those whose actions directly influenced AMU and AMR occurrence within the value chain and its production environment. Secondary stakeholders were those with indirect roles.

(d) *Key informant stakeholder interviews*– Information generated from the literature review and stakeholders' interview for the Aquaculture AMR Situation Analysis contributed to the stakeholder analysis. Key informants were identified and selected from both the public and private sectors to adequately represent the different segments of the aquaculture value-chain from production to fish health and marketing. They included farmers, representatives of line departments and agencies, professional associations, animal health diagnostic laboratories, and veterinary and fisheries practitioners. Questionnaires and checklists were developed to guide the interviews (Appendix 3).

(e) *Establishing influence and power relationships* - Based upon their levels of interest and power of influence, stakeholders were assigned roles in AMS and AMR surveillance as described below and elaborated in Table 1:

a. **Partners** – Stakeholders with the vested interest, resources and decision-making capacity to effect changes in practice within their designated value-chain areas.
b. Those to be **involved** for effective AMS and/or surveillance because of their high level of interest or capacity to influence change.
c. Those to be simply **informed** of surveillance status and outcomes because they have no direct interest or limited capacity to influence change.

Table 1 Categorization of Stakeholder Roles for aquaculture *AMU/AMR*

AMU/AMR Occurrence and Surveillance		Role
Level of Interest	Power of Influence	
High	High	**Partner**
Low	Low	**Inform**
High	Low	**Involve**
Low	High	**Involve**

The outcomes of the stakeholders' analysis are discussed in the subsequent sections of the report.

4.0. Categorises of Aquaculture Stakeholders

Stakeholders were categorized as primary or secondary stakeholders or as observer based on the roles they played in the sector's AMU and AMR (Figure 1).

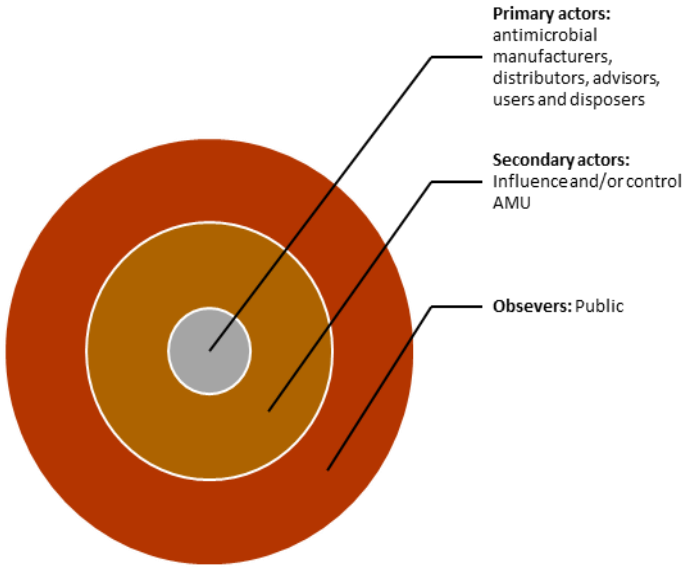

Figure 1. Relationship between primary and secondary stakeh*olders in aquatic species AMU/AMR*

Primary stakeholders were those who directly advised, manufactured, distributed, used and/or disposed of antimicrobials for the production of fish or fish products at any segment in the aquaculture value chain. As such, the primary actors were identified as being fish farmers, aquaculture extension workers, veterinarians, chemists and pharmacists, veterinary input manufacturers and suppliers, feed manufacturers, fish processors and traders, and livestock farmers.

Secondary stakeholders were those who influenced and/or controlled the access and use of antimicrobials by consumers by virtue of their institutional roles or aquaculture production resources they controlled. They included policy managers, government agencies and regulators, training and research institutions, consumers, producer and professional associations.

Observers were those who had no direct influence or control of AMU, except by expressing their views in the form of public opinions, such as the media and public.

The specific stakeholder roles and actions that influenced the occurrence of AMU/AMR within the aquaculture were influenced by diverse factors (Table 2). At the value chain level, stakeholder's specific roles was found to change in some instances. Thus, some of the stakeholders identified as secondary stankeholder during sector analysis become listed as primary stakeholders when their during the value-chain stakeholder analysis. The changes arose from the essential services they provided directly for aquaculture production and marketing (Table 3).

Table 2. Sectoral Overview of Aquaculture Stakeholders and their Roles in AMU/AMR

STAKEHOLDER CATEGORY	STAKEHOLDER ROLES	MAJOR INFLUENCERS
1. Primary Stakeholders		
Fish Farmers	• Fish production and marketing • Disease identification • Procure and administer antimicrobials for treatment or prophylaxis • Advisors to other farmers. • Ensure viability and profitability of their enterprises	• Experiences of other farmers or farmers associations • Regulated by FMARD
Feed manufacturers	• Procure antimicrobials • Produce medicated feeds • Ensure market competitiveness of their products	• Regulated by NAFDAC • Fish farmers
Aquaculture extension workers	• Advisory services for fish production, health, and marketing	• Public employees • Implement FMARD guidelines
Veterinarians	• Disease diagnosis • Collection and submission of samples for laboratory disease diagnosis, • Source and administer antimicrobials. • Advisory services on fish health and biosecurity control	• Regulated by the Veterinary Council of Nigeria (VCN) • Implement FMARD guidelines • Consultancy fees
Veterinary/Agro-Input manufacturers and suppliers	• Import, manufacture, and distribute antimicrobials and other medicines • Advice on selection and use of antimicrobials • Ensure viability and profitability of their businesses	• Market share • Regulated by NAFDAC • Implement FMARD guidelines • Experiences of their clients
Chemists/Pharmacies	• Distribution and dispensing of antimicrobials and other medicines, principally for human use. • Profitability of their businesses	• Regulated by NAFDAC • Pharmacists Council
Fish processors and traders	• Process, distribute and market aquaculture products • Administer antimicrobials as anti-stressors to improve shelf-life and product quality	• Regulated by FMARD (Certification and guidelines) • Market/business regulations
Animal disease diagnostic laboratories	• Confirm disease diagnosis and AST • Advice farmers and veterinarians	• FMARD • Universities • Agricultural research institutions • Private sector
2. Secondary Stakeholders		
Federal, state and local government departments of FMARD	• Policy formulation and governance • Disease surveillance and biosecurity control • Maintain database of aquaculture facilities	• Fisheries Department of FMARD is Competent Authority

	• Develop implementation tools - certification of aquaculture facilities and products, producer guidelines (Best Practices)	• NCDC • Regional and international agencies (OIE, ECOWAS, FAO, WHO, AU-IBAR)
NAFDAC	• Regulate and control quality, importation, manufacture and distribution of pharmaceutical products and animal feeds	• FAMRD advisory role • NCDC • Environment Authority • Regional and international agencies
FME	• Environmental protection, natural resources conservation and sustainable development • Regulate environmental management • Develop waste disposal guidelines	• Disposal of waste • FMARD • Regional and International agencies (ECOWAS, Global and AU environmental and agricultural treaties)
NCDC	• Public Health • One health AMR control	• FMARD • FME • FMH • Regional and International agencies (WHO, ACDC, ECOWAS)
Research and training institutions	• Train personnel (extension agents, veterinarians, and farmers) • Research and train laboratory staff • Generate and share knowledge	• Consultancy services to producers and practitioners • FMARD
Fish farmers, traders, and professional associations	• Share information • Maintain databases of their members Advocacy	• FMARD • Members experiences • Market influences
Professional bodies	• Regulate practices and register practitioners	• Veterinarians, pharmacists, aquaculturalists, health professionals • FMARD for fish inspectors
Consumers	• Consumer of aquaculture products	• Consumer associations • FMARD • NCDC
Observers		
Media	• Public awareness, • information dissemination and advocacy	• Ministry of information • Public • FMARD • NCDC

		• Producer and professional associations

Table 3. Stakeholders and their Roles in AMU/AMR across the Aquaculture Value Chain

FLOW OF GOODS AND SERVICES ACROSS THE AQUACULTURE VALUE CHAIN →					
VALUE-CHAIN SEGMENT	**UPSTREAM**	**CENTER**		**DOWNSTREAM**	
	Input suppliers and services	**Production**	**Post-harvest handling and processing**	**Distribution and Trade**	**Consumer**
FUNCTION	• Produce, source and/or supply inputs. • Provide technical, diagnostic, and advisory services to centre and downstream actors. • Marketing products and services	• Utilise inputs, natural resources, and services to produce fish. • Marketing	• Utilise inputs, services, and farmed fish to produce fish products. • Marketing	• Collect and accumulate fish produce and/or products. • Marketing • Distribution	• Selection and preparation of products • Consumption
PRIMARY ACTORS	• Feed manufacturers and suppliers • Equipment suppliers • Aquaculture technicians • Veterinarians • Laboratories • Agro and veterinary input suppliers • Chemists and pharmacists • Extension service providers (government services, advisors, training) • Suppliers of public goods and services (land, water)	• Hatchery producers • Grow-out/table fish producers	• Preservation and Value-addition - Live fingerlings and table fish - Smoking - Filleting and freezing - Barbecue	• Accumulators (market women) • Transporters • Wholesalers • Road-side sellers - smoked and frozen packaged products • Supermarkets – frozen, fresh, and smoked products • Restaurants/hotels – live, processed, and barbecued fish	• Households

AMU actions	• Procure, import, and manufacture AM • Supply AM • Prescribe AM (advise on when and how to be used) • Disease diagnosis • Advisory/recommendations • Market and Distribute AM • Storage of AM (bulk) • Dispose expired AM	• Purchase • Administer AM. • Dispose AM • Storage of AM on farm • Implement biosecurity measures on-farm. • Advise and distribute AM to other farmers.	• Purchase and use antimicrobials as an input for fish processing and transportation. • Sanitise premises and facilities. • Water treatment • Implement biosafety measures.	• Purchase and use antimicrobials as an input for fs.h processing and transportation. • Implement biosafety measures. • Add AM to fish handling containers and utensils	• Prepare and consume products
Actions that may promote AMR	• Stakeholders motives for prescriptions and adhering to ethics • Access and status of knowledge and skills	• Selection of AM is largely based on previous experiences of others/self and not on laboratory diagnosis • Non-observation of withdrawal periods • Prophylactic use of AM and medicated feeds • Use of AM-residue containing animal by-products	• Non-observance of withdrawal periods • Residues in products, by-products, and effluent • Methods used to dispose of and treat waste and effluent. • Occupational hazard e.g. exposure of injured workers to inputs with AM,	• Non-observance of withdrawal periods • Distribution of products and inputs with residues • Occupational hazard e.g. exposure of injured workers to inputs with AM, AM residues or resistant bacteria/genes	• Consume products with AM residues

		• Contamination of water sources and effluent with AM residues • Methods of AM administration, storage and disposal • Extra-label drug use • Occupational hazard e.g. exposure of injured workers to inputs with AM, AM residues or resistant bacteria/genes	AM residues or resistant bacteria/genes		

5.0. Current Status of AMS and Networking among Aquaculture Stakeholders

The capacity for AMS among stakeholders depends on their level of awareness and the resources and tools accessible to them to support implementation and commitment. The Aquaculture AMR Situation Analysis indicated that these factors were currently inadequate.

5.1. Stakeholders Level of Awareness of Aquaculture AMU/AMR

The level of awareness on AMR by primary stakeholders' was generally low (Table 4). The survey observed that some fish farmers (19.9%, 67/336), veterinarians and diagnostic laboratories (100%, 4/4) had had first-hand experiences with AMR in aquaculture. However, for the rest, AMR was a general concept yet to be appreciated as an issue in the aquaculture value chain. The lack of awareness among such such stakeholder was likely to have affected their compliance to sectoral AMU guidelines for aquaculture production, fish health management and disposal of farm waste and effluent with antimicrobial.

Table 4. Level of awareness of AMR/AMU in aquaculture among primary stakeholders

Stakeholder	Level of AMU/AMR Awareness*		
	High	Medium	Low
Fish farmers			Low
Feed manufacturers		Medium	
veterinary input suppliers			Low
Diagnostic laboratories	High		
Fisheries extension officers			Low
Veterinarians	High		Low
Fish farmers associations			Low
Livestock and poultry farmers			Low
Fish processors and traders			Low
Training Institutions			Low
Chemists/pharmacies			Low

*Level of awareness is respondents' response on AMR

5.2. Stakeholders' Capacity Needs for Aquaculture AMS

Stakeholders were asked to give their views on what interventions should be made to control of aquaculture AMU/AMR. Figure 2 below shows what the sectors stakeholders viewed as priority actions.

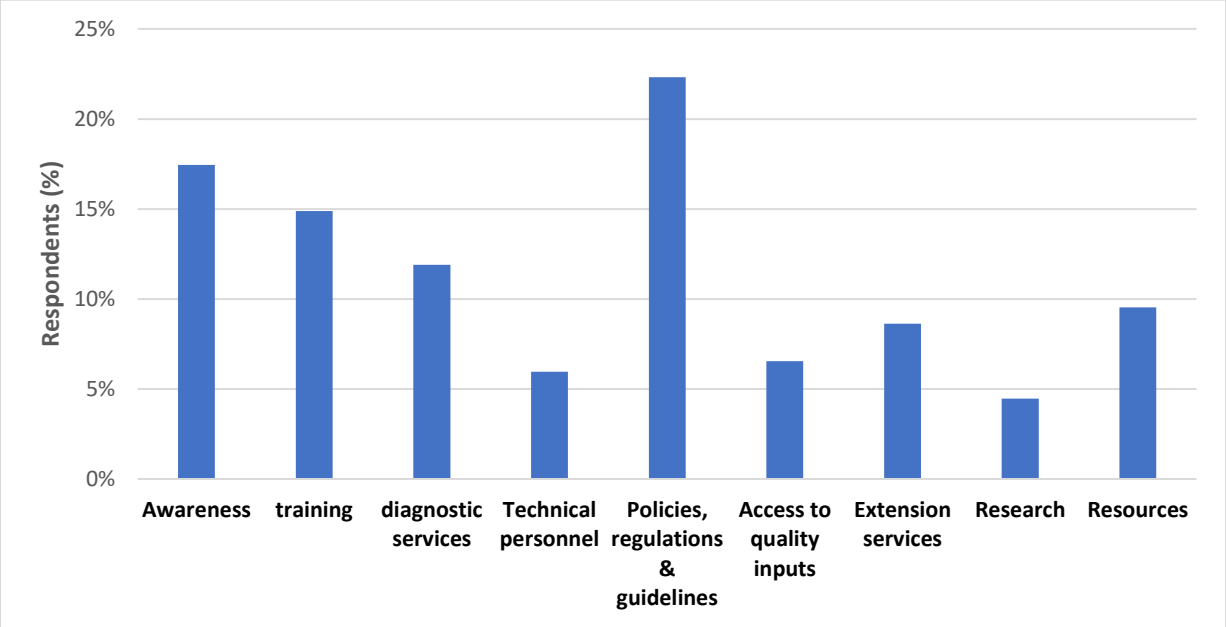

Figure 2. Respondents' recommendations for the control of AMU/AMR

Awareness creation – The general level of AMU/AMR awareness among all stakeholders across the value chain was quite low. Stakeholders within the sector and the public needed more information on best AMU practices and implications of AMR associated with aquaculture. Improved awareness would help reduce indiscriminate AMU. The levels of awareness must be maintained continuously to ensure sustained impact. Organic aquaculture, alternative methods for controlling fish disease and the use of quality feed inputs needed to be promoted. The engagement of the media to create public awareness for the control aquaculture AMU/AMR was necessary.

Stakeholder training – the continuous training for veterinarians, extension workers, and farmers to keep them up to date and capable of implementing recommended best practices in biosecurity control, disease diagnosis and management, calculation and application of treatments was raised. Tertiary curricula for veterinary medicine and aquaculture; as well as farmer training programs needed to be strengthened to ensure sufficient coverage of aquatic animal disease, biosecurity control and AMU/AMR.

Diagnostic services – The major constraints that limited access to and use of diagnostic laboratory services were high costs, distance to laboratories and lack of knowledge on the relevance of laboratory testing for the prudent use of AMU. Stakeholders needed more sensitization on the value of such services for the control of AMU/AMR.

Technical personnel – Veterinarians needed to be encouraged to become more involved in aquaculture because they were better trained and experienced in disease diagnosis and treatment. This was reiterated by farmers, feed manufacturers, laboratory personnel, veterinary input suppliers and extension agents.

Policies, regulations, and guidelines – Government needed to become more committed to implementing regulations, the standardization of aquaculture products and improving international awareness of Nigeria's farm products. The latter would help benchmark the industry against countries that have successfully implemented AMS and AMR surveillance in their aquaculture sector. The access to, control and use of antimicrobials also need to be restricted and more closely monitored. Stakeholders needed guidance and supported for the implementation of fish health management recommendations and AM residue monitoring in aquaculture products.

Access and quality of inputs – According to farmers and feed manufacturers, the poor quality (sub-standard) of feeds, feed ingredients and drugs on the market compelled them to use antimicrobials to prevent economic loss. Furthermore, AMs are accessible to fish farmers and traders from veterinary and human pharmacies without prescription. The effective implementation of existing regulations and dissemination of information on drugs/formulations approved for use in fish would reduce prophylactic and extra-label drug use.

Research – Investment into aquatic animal health research was required to the disease status and to identify and develop the most appropriate diagnostics and disease control tools for use in the country. Similarly, treatment regimens for approved drugs and the minimum drug residue levels needed to be developed and shared with stakeholders. Such information would promote and enforce behavioral change among stakeholders. The dissemination of research results and their adoption into common practice needed to be improved.

Resource mobilization – The need for financial support to enable stakeholders make the investments investments needed for the implemention of recommended guidelines was raised. For example hire more veterinarians as this would enhance the utilization of laboratory services by farmers, equip public and private-sector animal diagnostic laboratories to cater forfish diagnostic services, training of stakeholders, and improve the remuneration of government extension or veterinary personnel. Such investments would make diagnostics and otherfish health support services more affordable and accessible for fish farmers, feed manufacturers, input suppliers and fish processors.

5.3. Influence of Stakeholders on Aquaculture AMS

Findings from the Aquaculture AMU/AMR situation analysis indicated that farmers, fish farmer associations and veterinarians had a strong influence on AMU/AMR. The internet was a major source of misinformation for farmers (Appendix 4). Feed manufacturers and input suppliers also played a negative role by supplying antimicrobials to farmers without prescription.

Based on the stakeholders' level of interest and control over AMU/AMR, farmers, aquaculture extension workers, veterinarians, research and training institutions, feed manufacturers, fish farmer and professional organizations, FMARD and NAFDAC, were identified as having the greatest capacity to influence AMU/AMR practices in aquaculture (Table 5). The NCDC, regional and international agencies influenced the adoption of international best practices by the FMARD and the aquaculture sector as a whole.

To promoted the One Health approach in aquaculture, the Federal Ministries of Environment and Health (FME and FMH) need to become involved in the identification and monitoring of AMR and AMresidue hotspots and pathways for transmission across the aquaculture, environment and human

health sectors. Similarly, their contribution would elucidate the impact(s) of aquaculture AMR on human, animal and ecosystem health.

Table 5. Analysis of stakeholder's roles, interest level, and capacity to influence aquaculture AMU/AMR

Stakeholder	Responsibilities/Roles/Interests	Level of Interest in AMU/AMR	Power of Influence on AMU/AMR	Action
PRIMARY STAKEHOLDERS				
Farmers	• Fish farming • Use of antimicrobials to reduce mortality, increase productivity and profitability	High	High	Partner
Veterinary teaching hospitals and colleges	• Training • Knowledge generation • Outreach	High	Medium	Involve
Fisheries and Aquaculture Research Institutes	• Training • Research	High	Medium	Involve
National Fisheries Laboratory	• Certification of fish products and farms • Diagnostics • Provide advisory and clinical services to producer/industry	High	High	Partner
Veterinary Research Institute e.g. National Veterinary Research Institute (NVRI)	• Production of vaccines and offering services for the identification, control, and eradication of economically important livestock diseases, through best practices, research excellence	High	High	Partner
Private Diagnostic laboratories	• Profit • Diagnostics • Provide advisory and clinical services to producer/industry	High	High	Partner
Feed manufacturers	• Access to markets for feeds • Advise producers • Profits	High	Medium to high	Partner
Farmers organisations	• Share experience • Obtain and share information	Medium to High	High	Partner

	• Increase production • Advocacy			
Professional aquatic animal health service providers (private and public sector)	• Livelihoods and profit, • Advocacy	high	Low to medium	involve
SECONDARY STAKEHOLDERS				
Professional organisations: - NVMA - FISON - Environmentalists - Pharmaceutical industry/pharmacists	• Compliance with standards and ethics • Advocacy	High	High	Partner
Fish producer associations	• Livelihoods/profit, • Access to markets • Share best practices	high	Low to medium on policy	Involve
The National Agency for Food and Drug Administration and Control (NAFDAC)	• Regulate and control the manufacture, importation, exportation, distribution, advertisement, sale and use of food, drugs, cosmetics, chemicals, medical devices and packaged water in Nigeria for the protection of human health. • Feed-safety	High	High	Partner
FMARD	• Responsible for information and management of livestock pests, distribution of pesticides and provision of veterinary services. • National Veterinary formulary • Feed and fish safety	High	High	Partner
NCDC	• Public health • One health • Influence national formularies	High	High	Partner
FMARD (State and regional veterinary and fisheries officers)	• Animal health and compliance for purposes of trade, public health, food security and safety, animal welfare, livelihoods, and environmental integrity	High	High	Partner

Civil society (NGOs, CBO, farmer and other producer and industry associations)	• Advocacy	High	Medium	Involve
FME Wildlife, fisheries and environmental managers and conservationists	• Environmental sustainability Ecosystem health and services, • Biodiversity	Medium	Medium to high	Involve/partner
FMH	• Zoonoses and food safety	High	Medium	Involve
Other non-Governmental in-country projects or programs on aquaculture production and/or health/biosecurity	• Productivity • Livelihoods • Develop beneficiary capacity and practical skills • Adoption of best practices	High	High	Partner
Industry (manufacturers and suppliers of inputs)	• Sales volume and profit	High	medium to high	involve
Traders and transporters	• Sales volume and profit	high	low	involve
ECOWAS	• Regional harmonization and integration on transboundary animal disease control, animal and human movement, trade of commodities, regional risk mitigation,	High	High	Partner (through FMARD)
International multi-national partners (OIE, FAO, WHO, WTO, etc)	• Harmonization of international standards, implementation, policy development, resource mobilization, technical support	High	High	Partner (through FMARD)
OBSERVERS				
Consumers	• Food security, nutrition, and safety	High	Low to medium	Involve
Media	• Information dissemination • Income	Low	High	Involve
Public	• Information	Low	Low	Inform

6.0. Changes Required to Strengthen AMS in the Aquaculture Sector

Aquaculture stakeholders need to appreciate the uniqueness of aquaculture as a food production system. Water is indispensable in aquaculture. Fish are kept, fed, and treated in water; they release their waste products into the water within the same unit they are being raised in. The by-products or wastes of most human activities on land also eventually end up in the aquatic ecosystem. Fish farms are therefore, as equally exposed to AM residues, resistant organisms or resistance genes from environmental sources as they are likely to release the same into the environment. Depending on the characteristics of and activities within the surrounding aquatic habitats, there is a likelihood that fish farms can be located within the hotspots where AMR pathogens and antimicrobial residues accumulate and spread from.

The management of fish health, fish safety and public health in aquaculture is therefore closely linked to the control of AMR in the environment and environmental management. Strategies to promote the prudent and judicious use and the responsible disposal of antimicrobials need to take this interplay into account. Aquaculture stakeholders consequently have a vested interest and important role to play in the promotion of One Health approaches for antimicrobial stewardship.

6.1. The Aquaculture Theory of Change

The aquaculture problem tree or theory of change illustrates what changes need to be made to achieve antimicrobial stewardship in the sector (Table 6).

Table 6. The Aquaculture Theory of Change

Problem Tree	Objective Tree	Results Chain
Effects • AMR in fish, humans, and the environment as a result of antimicrobials misuse in aquaculture.	**General Objective** • Prudent use and disposal of antimicrobials in aquaculture.	**Impact** • Reduced AMU/AMR associated with aquaculture. • Improved aquaculture biosecurity
Core Problem • Non-regulated and unsupervised AMU in aquaculture	**Specific Objectives** • Surveillance and control of AMU and AMR by aquaculture stakeholders	**Outcome** • Prudent and judicious use, and responsible disposal of veterinary medicines in aquaculture
Causes 1. Low-level of AMU/AMR awareness among stakeholders 2. Inadequate diagnostic capacity for the accurate diagnosis of fish diseases **3.** Poor mobilization and coordination of stakeholders against AMU/AMR in aquaculture **4.** Lack of/weak institutional arrangements and collaboration among stakeholders for AMU/AMR surveillance and control	**Strategies** 1. Stakeholder mapping, relationship building, and behaviour change among stakeholders for AMS 2. Strengthen laboratory diagnostic and aquatic veterinary services 3. Develop partnerships and collaborative networks to foster compliance and stakeholder engagement/ownership **4.** Sustainability. Stakeholder engagement for resource mobilization and implementation of actions	**Outputs** 1. Aquatic species AMU/AMR stewardship and surveillance network established. 2. Governance and operational structures for AMU/AMR stewardship network established. **3.** Accurate and timely report of AMU/AMR data initiated.
Drivers of causes and proposed resolution activities		
Cause 1: Low-level of AMU/AMR awareness among stakeholders		

Drivers	Proposed Activities
1.1. No systematic AMU/AMR data collection in aquaculture 1.2. Inadequacies in existing government guidelines on the control of aquatic animal diseases, AMU and fish safety 1.3. Poor communication channels among stakeholders on aspects of aquatic animal disease control and AMR 1.4. Minimal public information dissemination	1.1. Conduct stakeholder mapping to identify key actors and subsequently create a stakeholder database 1.2. Review, develop and strengthen the capacity of stakeholders to adopt and implement Codes of Practice (COPs) and Standard Operating Procedures (SOPs) commensurate to government guidelines 1.3. Establish an efficient reporting, risk communication and public information-sharing system 1.4. Public awareness campaigns
Cause 2: Inadequate diagnostic capacity for diagnosis of fish diseases	
2.1. Limited diagnostic capacity among veterinarians, aquaculture practitioners and laboratories	2.1. Strengthen and make veterinary and laboratory diagnostic services more accessible to stakeholders 2.2. Expand laboratory networks by building the capacity of existing animal diagnostic laboratories for fish disease diagnosis 2.3. Establish and link laboratories to each other through harmonised Laboratory Information Management Sysems (LIMS) and networks.
Cause 3: Poor mobilization and coordination of stakeholders against AMU/AMR in aquaculture	
3.1. Stakeholders do not appreciate each other's roles in AMU/AMR. 3.2. The stakeholders work within silo's and do not share resources, knowledge, or information. They may talk to each other, but, do not work together. 3.3. Poor coordination and collaboration of activities among the different stakeholders irrespective of common sectoral goals 3.4. Low investment and resources for aquatic animal biosecurity and AMR surveillance	3.1. Develop and share a database of stakeholders and their roles in the value chain. 3.2. Establish a network as a forum through which different stakeholders can engage and work together and share experiences and knowledge towards common goals (i.e. AMR stewardship). 3.3. Conduct gap analysis and needs assessments and undertake commensurate capacity building of the resources, knowledge, and skills available among stakeholders to establish AMS and an effective AMS network. 3.4. Develop strategies to enhance Public-Private Sector Partnership (PPPs) for resource mobilisation and the implementation of key actions on aquaculture biosecurity and AMR control

Cause 4: Lack of/weak institutional arrangements and collaboration among stakeholders for AMU/AMR surveillance and control	
4.1 Weak collaboration between institutions and One Health sectors (e.g. between farmer's, professional organizations, research, environment, and public health departments) **4.2** Inadequate resources to effectively implement government guidelines for aquaculture establishments, biosecurity, veterinary drugs, fish food safety, trade & marketing and environmental management.	4.1 Establish a multistakeholder network comprising both public and private sector stakeholders. 4.2 Define roles and responsibilities for the network and its members. **4.3** Establish modalities for coordination, collaboration and development of partnerships in the sector through the network. (e.g. legal frameworks to create an enabling environment for joint partnerships in AMR stewardship)

6.2. Proposed Changes in the Behavior and Role of Stakeholders in the Aquaculture Sector

To promote AMS in the aquaculture sector, there must be some changes in attitude, behavior and roles of stakeholders. These changes are summarized in Table 7.

Table 7. Aquaculture Stakeholder Antimicrobial Stewardship Roles

Stakeholders	Current Role in AMU/AMR	Antimicrobial Stewardship Ideals	Proposed role in AMR stakeholder stewardship network
Primary Stakeholders			
Fish Farmers	• Disease identification, • Farmer to farmer advice on disease identification and treatment, • Procurement and administration of antimicrobials for treatment, prophylaxis, and increased production • Disposal of unused antimicrobials and effluent with antimicrobials	• Avoid indiscriminate use of antimicrobials; do not use them for prophylaxis or growth promoters • Ensure fish welfare and biosecurity on-farm to mitigate against and reduce incidences of disease on the farm • Monitor and restrict AMU within the limits and uses recommended	• Abide by the recommended government guidelines on aquaculture production, fish health management and biosecurity control, fish food safety, disposal of effluent and treatment withdrawal periods • Endeavour to seek professional advice from aquaculture extension officers, veterinarians, and/or laboratories for the diagnosis of diseases and AMU respectively • Use antimicrobials recommended for aquatic animals • Maintain accurate written records of fish production, health and AMU (notably cases of fish diseases and treatments used) • Participate in certification programs, seminars and other relevant educational programs • Report observations that may indicate treatment failure to your local diagnostician or State veterinary officer • Encourage other farmers to abide by the guidelines • Do not give or share unused antimicrobials with other farmers.

			• Only source antimicrobials from recommended sources
Feed manufacturers	• Procurement of antimicrobials, • Manufacture of fish feeds, including medicated feeds • Marketing and distribution of medicated feeds	• Avoid misuse and indiscriminate use of antimicrobials. • Use only approved fish drugs and feed additives from credible sources	• Abide by the government regulations on fish feed ingredients, manufacturing, packaging, and feed safety. • Stop adding antimicrobials to feeds as immune boosters and growth promoters. • Produce medicated feed only upon prescription. • Store and dispose of veterinary drugs following recommended government guidelines. • Advice farmers on the handling, storage, use and disposal of medicated feeds. • Maintain accurate written records on the production and distribution of medicated feeds;
Aquaculture extension workers	• Farmer training and advisory services on fish production, health, and marketing	• Promote and demonstrate to farmers and other stakeholders, how to adopt recommended best practices • Remain updated and timely disseminate information and relevant guidelines to fish farmers, fish processors and traders • Monitor and report sector trends to relevant State authorities	• Undertake and/or participate in relevant training and farmer or community sensitisation programs on AMU/AMR • Maintain an updated database of fish farms and regularly report the status of aquaculture farms in personnel's coverage area • Liaise with local/state veterinarian to ensure fish disease status and AMU records are up-to-date • Alert or seek advice from veterinarians/animal diagnostic laboratories on behalf of farmers on matters such as disease diagnosis and AMU, especially if the farmer(s) cannot access these facilities
Veterinarians	• Fish disease diagnosis and control	• Promote the judicious use and proper disposal of	• Abide by government regulations on AMU in aquaculture, and prescribe based on approved drugs listed in the Nigerian Veterinary Formulary[22]

	• Submission of samples for laboratory diagnosis • Recommend, supply and administer treatments, including antimicrobials	antimicrobials within the aquaculture value chain • Increase infection cure rates, reduce treatment failures, adverse effects, antibiotic resistance	• Make accurate diagnosis and obtain AST result before prescribing antimicrobials • Closely monitor and maintain accurate written records and reports on disease cases, diagnostic tools used, treatments and other control measures. Share these data with relevant authorities as recommended • Undertake and/or participate in relevant training and sensitisation programs on AMU/AMR for aquaculture value chain stakeholders • Discourage extra-label AMU and AMU for prophylaxis, growth promotion, shelf-life or product enhancement among users
Veterinary/Agro-Input suppliers	• Advice on choice and use of antimicrobials	• Stock, market and distribute only approved antimicrobials and other aquaculture inputs • Prevent extra-label use and misuse of therapeutic products	• Source, stock and dispense only approved fish antimicrobial drugs to the approved category of personnel • Maintain written records of antimicrobials sold for use in aquaculture facilities • Inform clients of good AMU/AMR practices
Chemists/Pharmacies	• Supply of antimicrobials to producers	• Stop the extra-label use and misuse of human therapeutic products	• Do not sell antimicrobial products designated for human use to fish farmers or fish processors to treat fish or reduce fish stress • Maintain written records
Fish processors and traders	• Administer antimicrobials as anti-stressor or shelf-life and product quality enhancers	• Prevent contamination of fish and water used for handling and processing of fish with antimicrobials or	• Follow government guidelines for post-harvest handling, processing, and marketing of farmed fish • Participate in fish safety and quality assurance programs • Remain updated on fish safety issues by attending seminars, media, and advice from extension workers.

		other potential food-safety hazards. • Stop abuse of antimicrobials in the post-harvest and marketing end of the aquaculture value chain	• Maintain written records of fish food-safety incidences
Animal disease diagnostic laboratories	• Private laboratories - routine first-line diagnostics • Confirmatory disease diagnosis, AST	• Participate in AMU/AMR surveillance and stakeholders' education • Accurate diagnosis	• Follow and maintain designated national NCDC AMU/AMR diagnostic laboratory standards and protocols • Ensure laboratory equipment are functional and well maintained • Generate and maintain databases on clinical isolates, AST results and AMR bacteria and genes • Manage and report data through the NCDC LIMS • Communicate laboratory findings to clients in writing • Educate veterinarians, extension workers, farmers and public
Secondary Stakeholders			
FMARD (Federal, state and local levels)	• Policy formulation, disease surveillance and biosecurity control maintain a database of aquaculture facilities, certification of aquaculture facilities and products, producer guidelines (Best Practices)	• Create a conducive environment for minimising and controlling aquaculture AMU and AMR • Promote AMR Stewardship • Assure the aquaculture value chain	• Secure, dedicate and sustain funding and other resources for effective implementation of antimicrobial stewardship • Monitor and control biosecurity and AMU in aquaculture following the one health and NCDC guidelines • Update and publicise the National Veterinary Formulary to reflect one health and NCDC recommendations • Update the national sector policies and guidelines to reflect AMU/AMR control in aquaculture • Maintain a one health national aquaculture database that shows the status of production, fish diseases, aquaculture biosecurity, AMU and AMR within the sector.

			• Implement residual monitoring (RM) plan in collaboration with other agencies and sectoral stakeholders. • Regularly revise policies, sector and farmers guidelines based on AMU/AMR and RM status reports. • Keep sectors stakeholders and the public well informed on AMU/AMR status • Establish and maintain effective communication channels between stakeholders and other health sectors • Educate aquaculture stakeholders on their roles and responsibilities • Sensitise and maintain public awareness of aquaculture AMU/AMR
Government agencies (NAFDAC, Standards Organisation of Nigeria)	• Regulatory agencies for the control of quality, importation, manufacture and distribution of pharmaceutical products and animal feeds	• Effective implementation of regulations and standards • Quality control • Promote AMR Stewardship	• Publicise and monitor implementation of regulations for the manufacture, distribution and use of antimicrobials, feed additives and other therapeutic agents • Promote and monitor adherence to national standards for all imported and locally manufactured aquatic animal drugs, feeds and products • Educate aquaculture stakeholders on their roles and responsibilities • Maintain national database on antimicrobial distribution and use in the aquaculture value chain
Department of Environment	• Environmental impact assessments	• Minimise the entry of antimicrobials and the establishment and spread of AMR resistant bacteria in the ecosystem. • Promote AMR Stewardship	• Monitor and control the pathways and drivers for AMU/AMR in the environment associated with the aquaculture value-chain[1] • Set guidelines for handling and disposing of waste and effluent from aquaculture

			• Set guidelines for other environmental activities that can lead to the use of AM or supply of water contaminated with AM residue to fish farms • Set guidelines for the disposal of unused antimicrobials and medicated feeds by farmers. • Organise sensitisation programs and disseminate information to aquaculture stakeholders and the public.
Research and training institutions	• Training of personnel (extension agents, veterinarians, and farmers), laboratory diagnostic services, research	• Generate new information on aquaculture AMU/AMR. • Develop tools and transfer knowledge to improve aquaculture AMU/AMR control practices for all the sectors stakeholders • Promote AMR Stewardship	• Human resource capacity building - training of sector stakeholders and practitioners on good AMS practices • Monitor, identify and develop interventions to minimise the occurrence of fish diseases, AMU and AMR • Monitor, identify and develop tools to address environmental, public health and food-safety concerns accruing to aquaculture • Research the application and benefits of good practice to students and aquaculture stakeholders
Fish farmers, traders and professional associations	• Information sharing, advocacy, maintain a database of their members	• Promote AMR Stewardship • Promote the adoption of good practices on aquaculture AMU/AMR control among members	• Share information and experiences on the benefits of adopting good practices on aquaculture production, biosecurity, AMU and fish food-safety • Promote the adoption of recommended good practices by establishing voluntary codes of conduct for members • Organise and/or encourage members to participate in training events. • Support and participate in media campaigns to public awareness on aquaculture AMU/AMR • Maintain an updated database of members and reports of activities implemented.

Professional bodies	• Regulate practices and register practitioners	• Promote AMR Stewardship • Promote the adoption of good practices on aquaculture AMU/AMR control among members	• Share information and experiences on the benefits of adopting good practices to control AMU/AMR in the aquaculture value chain. • Promote the adoption of recommended good practices by establishing voluntary codes of conduct for members • Organise and/or encourage members to participate in seminars and other training events. • Support and participate in media campaigns to public awareness on aquaculture AMU/AMR • Maintain an updated database of members and reports of activities implemented

7.0. Recommendations for an Aquaculture AMS Network

The economic losses arising from disease occurrences on farms are a major driver for AMU. The salient long-term consequences of antimicrobial misuse become immaterial for farmers and traders when faced with the threat of loss. Reducing the occurrence, impacts and spread of fish diseases during the farming, distribution and marketing of fish depends on one's ability to maintain fish welfare and health and to implement biosecurity control measures on the farm and environment.

Biosecurity, food safety and consequently AMS in aquaculture are multidisciplinary tasks that require the involvement of several stakeholders. The timely collection, analysis and sharing of accurate information are necessary for effective surveillance to control disease, AMU and AMR as well as ensure biosecurity. Information sharing between all stakeholders should be prioritized. Harmonized actions and collaborations between all entities (i.e. aquaculture producers, fish processors, fish feed formulators, traders, exporters/importers, national diagnostic laboratories, research facilities, training institutions, veterinary and fisheries field practitioners, specialists that include public health and environmental health specialists, SPS units and policy), will also make it possible to address the resource constraints and minimize the costs of biosecurity, AMU/AMR surveillance and disease control. An operational framework to harness resource capacities and coordinate stakeholders activities would strengthen the sectors capacity to establish one health population-based aquaculture AMR surveillance.

7.1. Aquatic Animal Health and AMR Network

The establishment of an integrated national aquatic animal health and AMR network is therefore recommended to promote AMS. The network will foster sustainable AMS considering that cases of disease and mortality pre-empt AMU in Nigerian aquaculture. The network will have three advocacy pillars: aquatic animal health and welfare, biosecurity control and aquatic environmental health. Advocacy will be aimed at preventing disease occurrence and spread, minimizing AMU and ensuring fish food safety and public health. Within the Nigerian context, these aspects define aquaculture AMS.

7.2. Objectives of the Aquaculture AMS Network

The network will be a forum of public and private aquaculture sector actors to[9,10]:

1. Network and coordinate actions to control aquatic animal disease and AMU/AMR control.
2. Share information on the surveillance and control of aquatic animal diseases, biosecurity and AMU/AMR in fisheries, aquaculture, and aquatic systems.
3. Develop and strengthen the capacity for harmonized epidemiological reporting and laboratory information management systems.
4. Collate and disseminate evidence-based information to advise industry and policy in these aspects as well as identify regional research and development needs and strategies.
5. Maintain an up-to-date stakeholder data-base and/or directory of producers and aquatic animal health services and service providers.
6. Disseminate database and directory information to network members and the public domain.
7. Foster AMS by promoting best practices and voluntary standards that will guide members.
8. Build public awareness and advocacy.

7.3. Proposed Stakeholder Roles for the Operation of the Network

A stakeholder's role is defined by the stakeholder's current roles in the aquaculture sector and their potential to influence AMS changes. There are three roles: A partner, an involved, and an informed stakeholder (Table 8).

It is also proposed that the FMARD will house the aquaculture AMS Network secretariat because the network's scope is within the FMARD's legal and institutional framework notably:

(i) Maintaining a database of fish farmers and collating national aquaculture statistics
(ii) Undertaking fish health surveillance and collating national fish health data
(iii) It has existing linkages with all stakeholders including other federal health departments
(iv) Its representation as a member of the AMR Technical Working Group.

Table 8. Analysis of Prospective Stakeholder Roles for the aquaculture AMS Stakeholders Network

Key Stakeholders	What is their interest	Level of Interest	Power of Influence	Action
Federal and State Government Departments (FMARD, FME, FH, NCDC, NAFDAC)	• Coordination • Resource mobilization • Strategy implementation • Policy • Supervision, monitoring and Control • Harmonisation of strategies between one health sectors • Controlled access to quality drugs • Standardisation of protocols	High	High	Partner
Development partners (USAID, US-CDC, DFID, B&M, IDRC, EU)	• Resource mobilization	High	Low	Involve
Regional and International Agencies	• Coordination • Resource mobilization • Support adoption and compliance to International Best Practices	High	Low	Involve
NGOs/Non-State Organisations	• Advocacy and awareness • Resources – Human & Financial • Implementation	High	Low	Involve
Academic and Research Institutions	• Human resource capacity building • Research to develop locally appropriate and cost-effective tools to support AMS in aquaculture. • Outreach	High	High	Partner

Veterinarians and Diagnostic Laboratories	• Maintain records of diseases diagnosed, AMU and AST lab results • Accurate disease diagnosis • Efficacy of treatments • Food-safety	High	High	Partner
Farmers	• Implement recommended best practices • Keep farm records of suspected disease cases, AMU and AMR	High	High	Partner
Farmer organizations	• Share information and experiences in best practices • Increased production • Access to markets	High	High	Partner
Veterinary and Agro-input Suppliers	• Compliance to the Nigerian Veterinary Formulary and regulations on drug distribution • Maintain records of all AM supplied and distributed	High	High	Partner
Fish feed manufacturers	• Compliance with recommended guidelines for the production and distribution of medicated feeds • Maintain records of medicated feeds produced and distributed • Responsible disposal of unused drugs or medicated feeds	High	High	Partner

Professional bodies (veterinary associations, PHA, animal handlers, pharmaceuticals, laboratories)	• Compliance with recommended practices • Promote compliance among members • Service delivery	High	Low	Involve

The above actions foster coherence and are likely to strengthen collaration among stakeholders for aquaculture antimicrobial stewardship.

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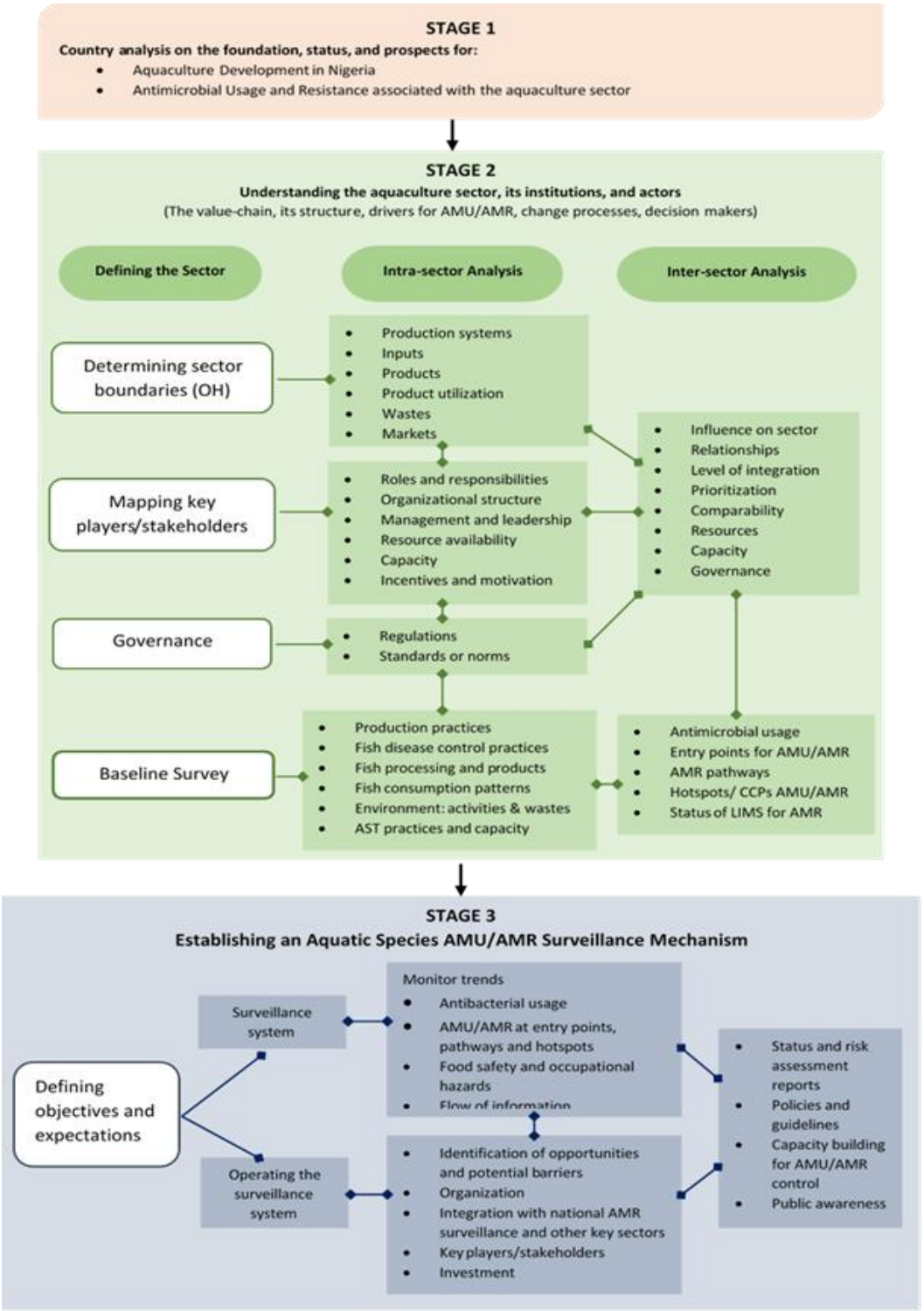
9.0. Appendices

Appendix 1: The Aquaculture PEA Framework



Appendix 2: Reports of Statkeholder Consultative Meetings

AMR Aquatic Species Surveillance PEA Framework

Stakeholder Consultative Meeting

Nelly Isyagi
8-8-2020]

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Acknowledgements

The consultant(s) is/are grateful to the following for their assistance in the production of this report:

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Abbreviations and Acronyms

AMU	Antimicrobial Use
AMR	Antimicrobial Resistance
GAP	The tripartite Global Action Plan on AMR
GLASS	Global Antimicrobial Resistance Surveillance System
LMS	Livestock Management Services
OH	One Health
OIE	World Animal Health Organization
PEA	Political Economic Analysis
NAP	National Action Plan for Antimicrobial Resistance (2017-2022)
NCDC	Nigeria Centre for Disease Control
FAO	Food and Agriculture Organization of the United Nations
WHO	World Health Organization of the United Nations

EXECUTIVE SUMMARY

There is growing concern globally, over the increased prevalence of Antimicrobial Resistance (AMR) associated with animal food value chains. The global framework for addressing this, hinges on the One Health approach and is set out in the tripartite Global Action Plan (GAP). The Government of Nigeria, under the auspices of the Nigeria Centre for Disease Control (NCDC) has also embarked upon addressing AMR in Nigeria's animal food value chains. A Country Grant was subsequently obtained from the Fleming Fund, to strengthen national capacity for AMR surveillance and control. Aquatic species were among the identified priority animal food value chains for this support.

It is a prerogative, that any established AMR surveillance system be robust in compliance to international standards and should also address the objectives of Nigeria's AMR National Action Plan and the GAP. Effective implementation and sustainability are additional key parameters. Hence, the Political Economic Analysis (PEA) was adopted as the preferred approach for establishing a foundation for aquatic species AMR surveillance in Nigeria. The approach was adapted to suit Nigeria's local context and an aquatic species PEA framework drawn. Given the rapid growth of the aquaculture sector where scanty information is available on antimicrobial use (AMU), it was agreed initially aquatic species surveillance should focus on aquaculture.

The PEA advocates stakeholder involvement and ownership in all steps of any action. A stakeholder consultative meeting to share stakeholder experiences and thus review the draft aquatic species PEA framework was set-up. A total of 23 stakeholders representing the Federal Department of Fisheries, Livestock Management Services, the private sector, academia, and DAI participated in this meeting.

The major outcomes of this meeting were:

(i) The adoption of the PEA approach for establishing the foundation for an aquatic species AMR surveillance system in Nigeria was supported.

(ii) In view of their likely impact for the establishment, effective implementation and sustainability of an aquatic species AMR surveillance system, the status of the following were identified as key areas for evaluation during the PEA:

- *Public awareness and sensitization of stakeholders* (also being a priority initial action)
- *Surveillance of farm aquatic animal health status*
- *Status of reporting on aquaculture*
- *Access to and use of antimicrobials*
- *Certification of aquaculture establishments*
- *Residue Monitoring and Control*
- *Quality of and access to aquatic veterinary services*
- *Diagnostic laboratory Services*
- *Food-safety -*
- *Training of personnel and producers in best practices*
- *Policy and Legislation Appropriate legislation*.
- *Establishing networks*

It was also agreed that the presentation and draft PEA framework be shared with participants for their final input.

MAIN REPORT

Background and Introduction

There is growing concern globally on the rising prevalence of Antimicrobial Resistance (AMR) and its implications for food-safety, human health, animal health and ecosystem health. An important pathway for AMR is through food value chains. Antimicrobials used in animal production, for example, largely belong to the same families as those used in humans. Residues often find their way into the environment and over time become part of the AMR cycle. In order to abate the development and prevalence of AMR globally, the Global Action Plan (GAP) against AMR was jointly developed by the World Health Organization (WHO), Food and Agriculture Organization (FAO) and the World Animal Health Organization (OIE) as a One Health initiative. To this end, the Global Antimicrobial Resistance Surveillance System (GLASS) was developed as a harmonized tool to support countries monitor and control AMR and to facilitate comparative analyses of global status.

In compliance to the GAP, the Government of Nigeria conducted a situation analysis of the country AMR status under the auspices of the Nigeria Centre for Disease Control (NCDC). The situation analysis found that Nigeria's AMR status was

broad, highly prevalent in humans, livestock, and the environment. In addition, chronic and community acquired diseases in humans were caused and treated by similar pathogens and antibiotics as domestic animals. Consequently, the National Action Plan for Antimicrobial Resistance (2017 – 2022) (NAP) was developed to reduce, prevent, and slow the evolution of antimicrobial resistant organisms and their impact on health care. The NAP recommended the establishment of an AMR surveillance system that integrates all One Health sectors if the objectives of the NAP and GAP are to be achieved.

Aquatic species play an important role in Nigeria's food value chain. However, domestic supply is inadequate. Imports of fish to supplement domestic supply are on the increase. Despite this, supply is still not adequate to cover the country's growing deficit for fish that is estimated at 2.2 million metric tons. Aquaculture is consequently being promoted to offset the deficit in domestic supply. Aquaculture production contributes 30% of domestic fish supply but the Nigeria National Aquaculture Strategy envisages that this contribution can be doubled if the sector's full potential of 2.5 million tons is fully realized. The prevailing environment has propelled commercial aquaculture development whereby more intensive production systems have been adopted and antimicrobial use (AMU) by farmers is on the rise. While there are some reports, the true extent and scope of AMU and AMR in Nigeria's aquaculture sector is not known. This makes it a risk for AMR especially if appropriate control measures in line with the NAP are not instituted for the sector. Aquaculture was therefore identified as among the priority animal food value chains for which an AMR surveillance system need be established by the NCDC and respective line ministries.

A Country Grant was subsequently obtained from the Fleming Fund to strengthen national capacity for AMR control in prioritized animal food value chains. The specific objective of the grant for aquatic species was to establish a foundation for AMR surveillance in aquaculture species. The expected outputs are:

(i) A situation analysis of AMR diagnostic capacity, and
(ii) A population-based AMR aquatic species surveillance system to generate data on resistance in aquatic species and pathogens relevant to human health.

In view of the fact that, the amount and quality of information available to support such an action was limited for aquaculture, the Mott MacDonald tool whose basis is the Political Economic Analysis (PEA) was adopted to guide the process. A framework to guide the process of establishing the proposed aquatic species AMR surveillance system for Nigeria using the PEA was developed as among the first steps for this assignment. This analytical tool has been adopted to develop a similar aquaculture AMR surveillance mechanism in Bangladesh.

The PEA uses methods from economics, sociology, and political science to understand how economic processes, political policies, and social institutions influence and affect the management and performance of policy, programs, and practice within sectors. They were not meant to be exhaustive nor prescriptive; but rather flexible and simple. The major objective a PEA framework was to facilitate a deeper understanding of local sectors and of how policy arenas function in order to identify entry points for development action. A deep sector analysis is consequently achieved whereby stakeholders themselves are empowered to identify the opportunities, issues and drivers for change and therefore develop comprehensive strategic actions to institute the desired changes. PEA normally follows a three-stage process:

(i) A country analysis that establishes the status and foundations of the sector and issues at hand.
(ii) A sectoral analysis to obtain an understanding of the organizations, institutions, and actors within the sector and how their structural features, power roles and ideologies drive and influence change in the sector.
(iii) Definition the entry points for action, the objectives, and expectations of proposed actions as well as modes of implementation and support for the recommended actions.

Purpose of the Meeting

The purpose of the meeting was to review the draft AMR aquatic species PEA framework with sector stakeholders to ensure it is well adapted to Nigeria's local context, and that the envisaged outcomes for the NAP and ultimately GAP could be achieved in a manner that also advanced the objectives of Nigeria's National Aquaculture Strategy.

Specific Objectives of the Meeting

The specific objectives of the meeting were to:
(i) Obtain stakeholder input into the proposed PEA framework for establishing a foundation for aquatic species AMR surveillance in Nigeria.
(ii) Share stakeholder experiences and lessons learnt on AMU and AMR within the sector.

Methodology

Twenty-three participants attended the meeting from government departments, the private sector and academia. The meeting was conducted online.

The meeting was opened with remarks given by officials from the donor DAI, Livestock Management Services (LMS) and the Federal Departments of Fisheries and Animal Health. Ms. Blessing Stephen on behalf of DAI gave an overview of the Fleming Fund Country Grant to Nigeria whose overall objective was to strengthen capacity for AMR. Dr. Bala Mohammed, the Animal Health Leader from LMS provided a general overview of the overall status of animal health and AMU and AMR within the animal production sector. He also facilitated the meeting.

Dr. Pwapso, the Director of Aquaculture from the Federal Department of Fisheries and Dr Dupe Ogunnoiki the National OIE Aquatic Animal Health Focal Point provided an overview of the national status of aquaculture development and aquatic animal health management, respectively. Dr. Dupe mentioned that Nigeria had embarked on efforts to address AMR in aquaculture about 10 years ago for which there had been some gains (see Annex 1 for the meeting agenda).

A power-point presentation that provided an overview of the proposed AMR aquatic species PEA framework was then delivered by the consultant after which the plenary was opened for discussion.

Outcomes of the Meeting

The participants appreciated and supported the proposed PEA framework as the approach to be used for establishing a foundation for AMR surveillance within the aquaculture sector. They however noted that since the level of public awareness was extremely low on AMR in aquaculture, it would be important that sensitization of producers and the public be brought to the fore front in the proposed aquatic species PEA framework. The benefit of this would be that when field work and stakeholder consultations commenced, the public would be aware and more co-operative.

The following is a summary of what participants viewed as being the status, opportunities, and envisaged challenges for establishing an aquaculture AMR surveillance system based on their experiences working with aquaculture policy, producers, and aquatic animal health:

- *Surveillance of farm aquatic animal health status* – Programs on aquatic health in the Federal Department of Fisheries were instituted about ten years ago. The aquatic animal health unit has developed a checklist that is used guide its staff when monitoring fish health status on fish farms. It was intended the fish farms in all states be regularly monitored. However, due to resource constraints, monitoring has so far been done in a couple of states, of which Lagos State was among. The major technical challenges they faced for the effective implementation of the monitoring plan were:
    - (i) The lack of laboratory and field diagnostic kits to support accurate diagnosis and prescription of treatments, and
    - (ii) Poor record keeping among producers, service providers and other stakeholders along the value-chain.

- *Status of reporting on aquaculture* - There was under-reporting in the sector. It would therefore be important to conduct in-country stakeholder consultations and a survey to ascertain more comprehensively the status of the industry in terms of aquaculture production and fish health during the PEA.

- *Access to and use of antimicrobials* - The country did not have its own approved drug list. It relied on the drug list recommended by FAO for aquatic species. Most of the drugs officially approved were already captured in the aquaculture regulations. This notwithstanding, it was common knowledge that farmers had access to and used unapproved drugs. The sources and distribution channels of these were not officially known. Furthermore, there were '*home grown'* treatment regimens used by farmers for disease control. Hence, the situation analysis and survey need generate data and information on:

    (i) The sources, distribution and administration of all drugs used by farmers in the aquaculture value-chain
    (ii) Procedures used by service providers and farmers to diagnose diseases as well as the treatment regimens used for conditions described.
    (iii) Assess how drugs are used or misused

    The data generated on the access to and use of drugs should help address the following for AMU/AMR surveillance:

    (i) The harmonization and standardization of valid 'home grown' treatments (as well as all others) against national and international standards

(ii) Nationally standardization and approved protocols for the diagnosis and control of aquatic animal diseases and biosecurity

(iii) Up-dated information and a database of sources, distribution channels and service providers in this aspect of the value-chain. This would help streamline and monitor service provision in accordance with official guidelines and requirements of the NAP.

- *Certification of aquaculture establishments* – A certification policy was put in place in 2009. Standards and guidelines for all fish farmers willing to certify their farms were already in place. These guidelines were being used for inspection. However, there was need for building the capacity of inspectors. The guidelines would also need to be up-dated based on the NAP and outcomes of the PEA.

- *Residue Monitoring and Control* - A program on residue control in the animal sector had been developed. During the process of its development, several of lessons learnt were captured in the progressive reports submitted in 2016 and 2018. These lessons would be useful for the aquatic species AMR situation analysis. There was now a residue monitoring plan in place however the drawback was no fixed separate budget line to ensure regular residue monitoring. This has affected implementation. The aspect of securing resources for aquatic species AMR surveillance should not be ignored during the situation analysis.

- *Quality of and access to aquatic veterinary services* - A major concern for the provision of aquatic veterinary services to farmers was *'Who are professionals being engaged by producers in the sector?'.* Farmers faced difficulties in getting profession help and so resorted to 'self-help' to diagnose and treat fish diseases. Often, they got advice from the wrong experts and thus several farmers had had their 'fingers burnt'. The need for standardizing certification, disease diagnoses and treatment protocols were raised as key concerns.

- *Diagnostic laboratory Services* – The status of aquatic animal diagnostic and food-safety laboratories needed improvement if they were to get accreditation and become ISO certified. Currently samples had to be sent for testing overseas whenever fish was destined for export. This was costly and time consuming. It would be more beneficial for the sector and for the implementation of biosecurity and AMR measures, if fish health and food quality laboratory services were locally available.

- *Food-safety* - The issue of food-safety was very pertinent when one considered farm practices which prompted the question *'What are fish farmers actually giving Nigerians to eat?*'. The capacity for fish-safety control along the entire spectrum of the aquaculture value-chain was necessary.

- *Training sector personnel, service providers and producers* - to build their capacity to adopt and implement best practices, including for AMR surveillance was key. The status of skills/needs assessment needed to be integrated into the PEA.

- *Policy and Legislation Appropriate legislation*. It was recommended that all fish farming activities be aligned with the NAP, LMS and aquaculture guidelines. In practice, this was yet to be fully the case. Another challenge affecting the comprehensive implementation on AMR was the lack of a national aquatic animal health structure. The information generated from the PEA should help inform policy on how best such gaps could be addressed for the benefit of fish health and AMR control.

- *Establishing networks* – It was apparent that there was a gap in the knowledge of stakeholder roles within the sector. Without this knowledge and stakeholder networking, it would practically be impossible to implement AMR surveillance. The outcomes from the stakeholder analysis should enable the development of a stakeholder database.

- *Public awareness and sensitization of stakeholders* - Sensitization and awareness should be brought forward. They were considered critical for the establishment and sustainability of the aquaculture AMR surveillance.

Next steps

1. The presentation and draft PEA framework be shared with participants to receive comments. Comments from this meeting and review of the draft shall be used to finalize the PEA framework as well as input into the situation analysis and design of survey tools.
2. Stakeholder consultation is important.

3. The date for an ensuing stakeholder consultative meeting to review the up-dated draft situation analysis will be set and communicated by DAI.

ANNEXES

Annex 1: Agenda of the Stakeholders Meeting to Review the Draft Aquatic Species PEA Framework, 5th August, 2020

Time	Session	Person Responsible
	Welcome Address	Dr. Bala Muhammad, LMS
	Introductory Remarks • Ms Blessing Stephen, Project Manager DAI • Dr. Dupe Ogunnoiki, Aquatic Animal Health Focal Point, Federal Department of Fisheries • Dr. Pwapso Istifanus, Director of Aquaculture, Federal Department of Fisheries	
	Review of draft aquatic species PEA framework	Dr. Nelly Isyagi, Consultant
	Plenary Discussion	All Participants
	Wrap up and Closure	Dr. Bala Muhammad

Appendix 3: Survey Tools Used

3.1. FARMERS QUESTIONNAIRE

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 30 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Farmers Signature: Date:

****

1. Questionnaire No.

2. Location of Farm *(GPS, physical address, town and state)*

Farmers Profile

1. Age (years) of farm owner_____
2. Gender of farm owner: **Male [ ] Female [ ]**
3. Highest Level of education achieved? **None [ ] Primary [ ], secondary [ ] tertiary [ ] Other [ ]**
4. What is the name of your farm? _____
5. When did you start farming fish?_____
6. Is the farm run as a family business or registered enterprise? **Family [ ] Registered Business [ ]**
7. Do you employ or rely on family labor? *(full time, part-time or both). Tick the box in the table below*

Source of Labour	**Full-time**	**Part-Time**
Family		
Hired		

*Describe tasks done in each category

8. Is it you who runs the farm? **Yes [ ] No [ ]**
9. If not run the farm, who does? **Manager [ ] family member [ ] other [ ]**
10. Has the manager/person running the farm received any specific skills training in fish farming? **Yes [ ] No [ ]**
11. If yes, in which topics have you obtained skills/information and who provided it to you? **Please tick the appropriate box**

Source of Skills/Information	**Yes/No**	**Internet**	**Fisheries extension/vet**	**Other farmer(s)**	**Training Center/Univ**	**Did you have to pay (Yes/No)**	**Amount Paid (Naira)**
Feeding fish							
Water quality management							

General fish farm maintenance							
Record keeping							
Fish health management							
Treatment of fish (administering drugs)							
Post-harvest handling/processing							
Marketing							

Additional comments if any: _____

12. Are you a member of any association/network? **Yes [ ] No [ ]**
13. If you are a member of an association, please mention the name and type of organization you belong to?
    Name of Association: _____
    Type of organization: Fish farmers [ ] mixed farmers [ ] traders/market [ ], professional [ ]

Production System

1. What is the production focus of your fish farm and which species do you raise? *Please tick appropriate box.*

Species raised	**hatchery**	**Grow-out**	**Both**
Tilapia			
African Catfish			
Other catfishes/hybrids			
Shrimp			
Other species _____			

2. Do you also raise other and crops on the farm? **Yes [ ] No [ ]**
   Please name them _____
3. Which culture and production methods do you use? *You may tick more than one*

Ponds		**Tanks**		**Cages**
Static water		Static water		
Flow through		Flow through		
extensive		RAS		
Semi-intensive		hapas		
monoculture				
polyculture				
Integrated aquaculture				
hapas				

4. Which inputs do you use?

Inputs	**Source**	**Average cost**
broodstock		
fingerlings/fry		
feeds		
drugs		
disinfectants		
Inorganic fertilizers		
manures		

5. What is your average annual production? _____
6. Where do you source your water for farm use? **River [ ] Borehole [ ] Spring [ ] Lake [ ] Dam [ ] roof-top [ ] Swamp/wetland [ ] Tap water [ ] Deep well [ ] Stream [ ] Others _____**
7. Mention and describe other activities found upstream or around your farm?
8. Does effluent/water from these places drain into your farm water source(s)?
   Yes [ ] No [ ] Do not know [ ] .
   *If yes, please explain*_____

Biosecurity Measures on Farm

1. What measures do you take to:

(i) ensure diseases or pests do not enter or leave your farm _____

(ii) affect the fish or your water sources _____
(iii) spread on the farm? _____
(e.g./*also mention/note diseases, treatments, disinfection regimes, vaccinations, pre and probiotics, diets/feed additives, etc.)*

2. What investments have you had to make for this(these) *(e.g. fencing, screens, the costs, isolation units, etc.)?*
3. How do you dispose of dead or sick fish/animals? **Bury [ ] Burnt [ ] Thrown into drainage [ ] Fed to other animals/fish [ ] Thrown into bush [ ] Open rubbish pit [ ] Nothing [ ] Other**
4. How do you handle *predators and other non-targeted/wild animals/fish inclusive*?
5. Do you keep farm records on production, fish health, treatments used, their costs? If so, what is contained in the respective records?

Records kept	Frequency *(daily, weekly, monthly, irregular, never)*	Content *(circle/tick as appropriate or add an extra)*
Production (unit)		*Species stocked, age, Fertilization, aeration, stocking, harvest, sampling - growth, etc.*
Feeding		*Feed type, quantity consumed, feeding response*
Water quality		*e.g. O_2, NH_3, Temperature, flow rate, etc.*
Fish health, diseases, treatments		*Species, symptoms, number affected, mortality, diagnosis/disease, treatment given, etc.*
Financial		*Expenses and income*

Antimicrobial Use on Fish

1. Do you give antimicrobials to fish on farm? **Yes [ ] Sometimes [ ] Never [ ]**
2. When do you use them? _____
3. What makes you decide whether to use antimicrobials? _____
   Disease/sick [ ] Cost of medication [ ] reduce mortality [ ] reduce spread [ ] improve growth rate [ ]
4. Do you engage the services of laboratories before using antimicrobials? **Yes [ ] No [ ]**
5. Can you please provide a record of your use of antimicrobials (which (brand), when, how much, why, how did you use or give them to the fish, where did you get information on how to use the antimicrobials)?
6. Where did you get the recommendation and/or information on how to use the antimicrobials you have mentioned?
7. How do you administer antimicrobial treatments? *(fish, water, feed, post-harvest handling, processing, market)*
8. Do you sell or distribute fish you have treated? **Yes [ ] No [ ]**
9. Do you observe withdrawal periods? **Yes [ ] No [ ]**
10. How do you dispose of the water/medium through which you administered the anti-microbials?
11. How do you dispose of antimicrobials you no longer need or have expired?
12. How to you store antimicrobials on the farm? **Yes [ ] No [ ]**
13. Who has access to the antimicrobials? _____
14. Who is responsible for administering antimicrobials or can any of the personnel do it? *Please explain*.
15. What benefits have you obtained by occasionally or regularly using antimicrobials in your production and marketing *(e.g. yields, survival, profits, shelf-life, appearance of product, taste, reduction of disease spread or severity, etc.)*

Antimicrobial Resistance

1. Have you ever experienced situations where your antimicrobial of first choice did not work? **Yes [ ] No [ ]**
2. *Please explain what happened and how you overcame the challenge. Also mention the antimicrobials or any other pharmaceutical or management measures you took to address this challenge*.
3. How many times/how often have you experienced treatment failure?
4. Whom did you approach for advice on how to overcome treatment failure?
5. Please describe the production, cost and other consequences you have experienced as a result of the treatment failure(s)?

Post-Harvest Handling and Marketing

1. Describe how you handle fish after harvest? _____
2. What facilities/equipment do you use for harvesting, post-harvest handling and transportation of products?
3. Are there sanitary or other measures you employ during this process? **Yes [ ] No [ ]**
   Please describe *(e.g. where you source water, is it filtered/screened, disinfect nets between use, etc.)*.
4. Do you add antimicrobials to fish water during transportation or marketing? **Yes [ ] No [ ]**
5. If you yes in (4) above, why? _____

6. Where do you sell your fish? _____
7. Which farmed fish products do you produce for sale? *(e.g. live fingerlings, live table fish, fresh whole, fillets, chilled on ice, smoked, etc.). which inputs and ingredients go into their processing or storage for market?*

Product	Species	Input/ingredient post-harvest
Live fingerlings		
Live table fish		
Fresh whole		
fillet		
chilled		
smoked		
other		
other		

8. Are there standards your client or the state demands of your produce or products?
Yes [ ] No [ ]
9. If so, please mention them _____
10. How do you meet these standards? _____
11. Do you process fish on your farm? **Yes [ ] No [ ]**
12. If so, where do you source the water used in handling, processing, and packaging fish for sale after harvest?
13. What are the costs of these (i.e. items in your enterprise budget – inputs, sales, etc.).

Disposal of Effluent/Wastes and Environmental Management

1. How do you dispose of the waste or water from your production, post-harvest handling and marketing units/activities? _____
2. Are you aware of any government guidelines on these? **Yes [ ] No [ ]**
   Mention them and the ones you implement?
3. What investments have you had to make to implement these guidelines?
4. How has implementing/following these guidelines benefited your operations, access to markets, community, etc.?

Sources of information and service delivery

1. Where do you get information, specific skills training, and/or technical support on the different specific aspects *(production, marketing and market information, fish health control, government regulations and standards, etc.)*? *(e.g. other farmers, newspapers, internet, social media, feed manufactures, agro-input dealers, extension workers, veterinarians, consultants, radio, associations, institutions, etc)*

   Please tick.

Source of Information	**production**	**Marketing/market information**	**Fish Health and Biosecurity control**	**antimicrobial use**	**Environmental issues**	**Government regulations /standards**
Other farmers						
News papers						
internet						
Social media						
Feed manufacturers						
Agro-input dealers						
Extension workers						
Veterinarians						
Consultants						
Radio						
Associations						
Institutions (training colleges, universities)						
NGO's						
Other						

2. How much does it cost you to get information or training from the sources you mention?
3. Is the information readily accessible? **Yes [ ] No [ ]**
4. What are your comments on the status of information and availability of information and technical support? *(include suggested recommendations for challenges met)*

General Comments

1. In your own words, what is your understanding of AMU/AMR and its relevance to your business? and to society?
2. What do you think you can do? Or the community can do to control it?
3. Do you have any other questions/comments?

A3.2. FEED MANUFACTURERS

Date and Time: _____

Enumerators Name: _____

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 20 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Company's Name: _____

Respondent's phone no.: _____

Signature of Company Representative: _____

****

1. Questionnaire No.

2. Location of Farm *(GPS, physical address, town and state)*

General Information

1. Which year did you start manufacturing fish feed for producers? _____
2. How would you categorize the nature of animal feed producer are you?
   On-farm feeds [ ] small-scale unmechanized [ ] medium-scale manufacturing [ ] large-scale manufacturing [ ]
3. Which animal feed products do you produce? *Please list*
   _____
4. What is the average annual production (in tons) of each of the feed types you produce? Including overall total?

Type of Feed	Average tonnage produced/year

Feed Manufacturing Processes and Products

1. What ingredients do you use and where do you source them from?
2. Do you have a quality control/recording system to track the ingredients used, their source and quality? **Yes [ ] No [ ]** *If yes, may we have a look at the records?*
3. Do you add feed additives to the feed? **Yes [ ] No [ ]**
4. If yes, which additives do you add, when and why? _____
5. Have you ever produced medicated feed for farmers? **Yes [ ] No [ ]**
6. If so, for which specific feed products has this been done, when and why?
7. Who gives you the recommendations on the dosing/mixture rates and on how medications should be incorporated into the feed? _____

8. Do you have records of medicated feed that has been produced and to whom it has been dispatched/requested for it? **Yes [ ] No [ ]** *If yes, may we have a look at the records?*

9. What is typically on your feed labels?

10. Do you label your medicated feeds to show which medication (feed additive) has been added along with specific recommendations for handling, storage and use on farm?
Yes [ ] No [ ]. *Or is this left to the person who gave the specific request to follow-up?*

11. How do you dispose of unrequired ingredients or unused/expired feed additives or medications?

12. Have you ever experienced a situation whereby the ingredients, feed additives or medications you procured for manufacturing feed have been sub-standard? **Yes [ ] No [ ]**

13. If so, briefly explain under what circumstances this occurred/or situations under which it most frequently occurs and how you disposed of the respective undesirable ingredients, feed additives, or medications.

Distribution, Marketing and Sales

1. Who are your major clients that purchase directly from your establishment?
2. Based on your knowledge, what is the geographical reach of the various feed products? *(i.e. states where it is sold/used)* _____
3. Typically, how is the distribution done of your feeds to the end-user?
4. Are there any differences in how distribution is done for the different feed-types and clients?
5. Do you have a system of calling-back and disposing of products that may have gone bad/found to be substandard from the market? *(i.e. do you have a traceability system for your feed products?)* **Yes [ ] No [ ]**
6. What means are used to bring in ingredients? *Please describe e.g. smallholders may use open bicycles, uncovered pickups, etc.* _____
7. What means are used to distribute your products to your clients? *Please describe e.g. smallholders may use open bicycles, uncovered pickups, etc.*

Advisory services given to fish and other farmers

1. Do you provide advisory services to transporters, agro-input dealers, and farmers on how to handle, store and use the feed? **Yes [ ] No [ ]**

2. What feedback have you obtained on your feeds? *(be it positive or negative)*

General Remarks

1. Do you have additional comments or questions to ask?
2. Based on your experience, what suggestions would you give to abate the misuse of antimicrobials and AMR arising from feed manufacture and use?

A3.3. VETERINARY INPUT SUPPLIERS (FEEDS, FEED ADDITIVES, DRUGS)

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 15 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Company's Name: **Respondent's phone no**.:

Signature of Company Representative: **Date**:

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1. Questionnaire No.

2. Location of Farm *(GPS, physical address, town and state)*

General Information

1. What are your qualifications/qualifications of the person who runs the business daily? *(and their name and contact if different from above)* _____
2. Describe your clients. *(i.e. are they farmers, which type of farmers, smallholder, large scale, rural/urban, etc.)*
3. What products and services do you provide clients?
4. Are any of these tailored to meet the needs of fish farmers, processors, or traders?

Yes [ ] No [ ]

5. How do you tailor your services to meet the needs of your clients? *(e.g. re-packaging, accessibility to and for clients, use of phones, structure of consultation fees/payments, etc.?).*

Veterinary Inputs Stocked for Aquaculture

1. What products do you stock for fish farming and where do you source them from?

Product Sold to Fish Farmers	Source

2. How do you store these items?
3. Of these commodities, which has the highest turnover?
4. Do you have an idea of which type fish farmers use the various commodities and how they use them on-farm?
5. Do you give them advice on the use of these items (including medications)?
   Yes [ ] No [ ].
6. If yes, what sort of advice do you give them?
7. Other than yourself, based upon your knowledge, who else gives advice to fish farmers on which inputs (including medications) to purchase and on their use?

Veterinary Medicines

1. In you view/based on your records, what are the most common fish health problems farmers describe to you?
2. How are diseases diagnosed before treatments are recommended?
3. Do farmers come to purchase medications with prescriptions?
   Yes [ ] No [ ] Sometimes [ ]
4. May you provide the details of medications prescribed or those fish farmers use when they have fish health problems? _____
5. Do you have records on what quantities of medications mentioned above have been purchased to treat fish? **Yes [ ] No [ ]** *If yes, can you please share the information*.

General Remarks

1. Do you have additional comments or questions to ask?
2. Based on your experience, what suggestions would you give to abate the misuse of antimicrobials and AMR arising in fish farming in the country?

A3.4. FISHERIES/AQUACULTURE EXTENSION OFFICERS

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 20 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Signature: **Date**:

****

1. Questionnaire No.

2. Location

Production Practices

1. What different fish farming systems are practiced in your area of operation?
2. What specific management practices accrue to each of the production systems?
3. Are the fish farmers, processors and traders aware of AMU?
   Yes [ ] No [ ] Not sure [ ]

4. What are the common fish diseases in the area/production system?
5. What diseases control measures are used for each of the disease conditions you have mentioned?
6. Who provides guidance? _____
7. In the event that antimicrobials are used, are laboratory diagnostic tests done prior?
   Yes [ ] No [ ] Not always [ ] Not sure [ ]
8. Where samples are taken to the lab prior, who collects and takes the samples? **Farmer [ ] Extension agent [ ] Veterinarian/Fish disease specialist [ ] Other** _____
9. Name the diagnostic laboratories are commonly used by producers in your area?
10. Where do fish farmers tend to source antimicrobials when they use them?
11. Do you know whether or not fish farmers comply with withdrawal periods after treating fish? **They do [ ] Some do [ ] Never do [ ] Do not know [ ]** *Explain* _____
12. Do you know how fish farmers store and dispose of unused antimicrobials on farm?
13. Are fish farm water sources and effluent routinely monitored for microbial loads or AMR? **Yes [ ] Rarely [ ] No [ ] Do not know [ ]** *If monitored, what are the common findings?*
14. Do farmers sometimes need to have their fish tested for bacteria or other residues prior to marketing? **Yes [ ] No [ ]** *Explain* _____

General Comments

A3.5. FIELD VETERINARIANS

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 20 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Signature: **Date**:

****

1. Questionnaire No.

2. Location *(GPS, physical address, town and state)*

Veterinary Medicines

1. In you view/based on your records, what are the commonest fish health problems farmers describe to you?
2. How are diseases diagnosed before treatments are recommended?
3. What is the likelihood that laboratory tests are done prior to antimicrobial prescriptions being given?
4. Are prescriptions given? *Explain* _
5. May you provide the details of medications you have prescribed or that fish farmers use when they have fish health problems?
6. Do you have records of what quantities of these have been purchased to treat fish?
   Yes [ ] No [ ] *If yes, can you please share the information*. _____
7. Have you ever done/recommended microbial testing of any of the following: farm water sources, production water, feed, fish and/products and farm effluent water?
   Yes [ ] No [ ]
   Explain what was done and what the findings and recommendations were?

Item Tested	Tests Done	Findings/action recommended

8. Based on your experience with stocking and supplying inputs for fish production, are there any specific feed additives, drugs that in your view, the market needs or is lacking? *Explain*
9. Do you have basic field diagnostic tools needed for fish diseases? *(e.g. water quality kit, light microscope, etc)*

General Remarks

1. Do you have additional comments or questions to ask?
2. Based on your experience, what suggestions would you give to abate the misuse of antimicrobials and AMR arising in fish farming in the country?

A3.6. LOCAL ANIMAL DIAGNOSTIC/FISHERIES LABORATORIES

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 10 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Company's Name: **Respondent's phone no**.:

Signature of Company Representative: **Date:**

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1. Questionnaire No.

2. Location *(GPS, physical address, town and state)*

Laboratory Samples and Tests

1. Which are the commonest tests requested for fish? *Please list in increasing order of importance*
2. Who requests for these? **Farmers [ ] Fisheries extension [ ] Veterinarians [ ]**
Fish food safety inspectors [ ] Others _____
3. Which samples are brought in most for testing?
4. How are samples brought to the laboratory?
5. What is the status of the samples? Explain *(e.g. if good or bad, status labelling, etc.)*
6. Which protocols do you use for the tests required?
7. How do you give feedbacks to your client?
8. Do you have records of recent tests? **Yes [ ] No [ ]**
9. What are the common antimicrobial resistance patterns you have observed?

General Remarks

1. What is the status of your ability to undertake required diagnostic and anti-sensitivity tests, traceability and give feedback to clients
2. Any other remarks and suggestions for improving the monitoring and control of AMR in fish.

A3.7. FARMED FISH/FISH PROCESSORS AND TRADERS

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 10 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Signature: **Date**:

****

1. Questionnaire No.

2. Location *(GPS, physical address, town and state)*

Post-harvest Handling and Food-safety

1. How is the fish from farms handled after harvest and enroute to the processing plants or markets?
2. Where do you source the water you use for handling and processing fish?
3. Have you ever taken this water for microbial testing? **Yes [ ] No [ ]**
4. Are there chemicals/drugs you use to improve water quality during handling, processing, or marketing? **Yes [ ] No [ ]**
5. If yes, please name and state the circumstances under which such chemicals/drugs have been used.
6. Where do you source the chemicals/ drugs?
7. Who give you recommendations for their use?
8. Are there government guidelines you follow in your business? **Yes [ ] No [ ]**

Marketing and Consumer Preferences

1. How do you sell your fish/products on the market?
2. Which are the most popular products? And why? *Please rank in order of increasing importance*
3. How do your consumers prepare these at home?

General Remarks

1. What would you suggest for controlling the use of antimicrobial in fish production?
2. Any other comment?

A3.8. LIVESTOCK AND POULTRY FARMERS IN THE VICINITY

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 10 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Signature of Company Representative: **Date**:

****

1. Questionnaire No.

2. Location of Farm *(GPS, physical address, town and state)*

Production and Water

1. Which livestock/poultry do you rear?
2. Do you also raise fish on your farm? **Yes [ ] No [ ]**
3. If yes, which production system do you use to raise the fish? *Also mention the fish species raised*
4. Are there fish farms in the vicinity of your farm? **Yes [ ] No [ ]**
5. Do you use antimicrobials to treat animals on the farm? **Yes [ ] No [ ]**
6. Please list the antimicrobials you used against the diseases they are used to treat/control?

Antimicrobial	Disease (s)

7. Are any of the farm's by-products used to rear fish on your farm or on other farms? **Yes [ ] No [ ]**
8. If yes, please mention them _____
9. Describe how you handle water effluent from your farm?
10. Where does the farm effluent drain into?
11. Are there fish farms downstream that use the surface water into which you discharge your effluent as their source of water for production? **Yes [ ] No [ ]**

A3.9. FARMERS ASSOCIATIONS

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 10 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Signature: **Date:**

****

1. Questionnaire No.

General Questions on Farmers Practices

1. How many farmers are in the association? _____
2. Which systems of production do your members use? *Please list starting with the commonest.*
3. Are you aware of any farmers who use antimicrobials? **Yes [ ] No [ ]**
4. Under what circumstances are antimicrobials commonly used by farmers?
5. Who normally provides advice and guidelines to farmers and traders on the use of antimicrobials?
6. Have members of the association received any training on drug use in aquaculture?

General Remarks

A3.10. FISH MARKET ADMINISTRATORS

Date and Time:

Enumerators Name:

This survey is aimed at improving fish and human health and establishing surveillance system on antimicrobial use/ antimicrobial resistance in aquatic species in Nigeria. It will take about 10 minutes of your time to fill. Thank you for your cooperation.

I ……agree that purposes for which this survey is being undertaken, has been duly explained to me in a language that I understand, and assured of confidentiality of any information passed on to the research team. Based on this, I agree to take part in the survey and understand that the data collected will only be used for the purpose stated therein.

Phone number:

Signature: **Date**:

****

1. Questionnaire No.

General

1. How many stalls sell farmed fish in the market? _____
2. Are farmers required to obtain permits permitting them to transport and bring farmed fish to market for sale? **Yes [ ] No [ ]**
3. If so, please mention the permits and the agency responsible for giving these permits
4. What are the basic standards farmed fish need to meet to be sold for human consumption?
5. Are farmers and/or traders generally compliant to these?
   Yes [ ] No [ ] Sometimes [ ]
6. If not, what challenges do traders or the farmers face with regard to meeting standards?
7. Are there cases of addition of chemicals and drugs to fish?

8. Is microbial testing ever done of the water used at fish stalls or tanks for holding live fish? *Explain including results*
9. What is done when products are found to be substandard?
10. Are there government guidelines shared with producers and traders? If so which ones?

General Comments

Appendix 3: Sources of Information for Farmers

Source of Information n = 336	Production	Marketing/market information	Fish Health and Biosecurity control	Antimicrobial use	Environmental issues	Government regulations/standards
Other farmers	248 (73.8%)	247 (73.5%)	230 (68.5%)	203 (60.4%)	202 (60.1%)	182 (54.2%)
Newspapers	21 (6.3%)	20 (6.0%)	20 (6.0%)	17 (5.1%)	26 (7.7%)	29 (8.6%)
Internet	124 (36.9%)	108 (32.1%)	107 (31.9%)	93 (27.7%)	82 (24.4%)	76 (22.6%)
Feed manufacturers	62 (18.5%)	56 (16.7%)	53 (15.8%)	45 (13.4%)	37 (11.0%)	35 (10.4%)
Agro-input dealers	34 (10.1%)	36 (10.7%)	27 (8.0%)	28 (8.3%)	20 (6.0%)	16 (4.8%)
Extension workers	57 (17.0%)	55 (16.4%)	57 (17.0%)	52 (15.5%)	67 (19.9%)	66 (19.6%)
Veterinarians	43 (12.8%)	29 (8.6%)	51 (15.2%)	54 (16.1%)	27 (8.0%)	26 (7.7%)
Consultants	27 (8.0%)	20 (6.0%)	15 (4.5%)	19 (5.7%)	10 (3.0%)	13 (3.9%)
Radio	19 (5.7%)	18 (5.4%)	10 (3.0%)	9 (2.7%)	14 (4.2%)	22 (6.6%)
Associations	144 (42.9%)	142 (42.6%)	137 (40.8%)	121 (36.0%)	123 (36.6%)	126 (37.5%)
Institutions (training colleges, universities)	N/A	N/A	60 (17.9%)	N/A	N/A	50 (14.9%)
NGOs	45 (13.4%)	38 (11.3%)	30 (8.9%)	28 (8.3%)	30 (8.9%)	27 (8.0%)
Other*	11 (3.3%)	15 (4.5%)	13 (3.9%)	28 (8.3%)	40 (11.9%)	49 (14.6%)

**Others include no information; NAFDAC, Lagos State Ministry of Agriculture*

(Adapted from Nigeria Aquaculture AMR Situation Analysis Report)