Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

AMR Surveillance in Aquatic Animals: Key Considerations

Antimicrobial Resistance (AMR) in Aquaculture

5th October 2023, Kigali, Rwanda

Bin Hao

Fishery Officer, Food Safey, Nutrition and Health Team
Food and Agriculture Organization of the United Nations (FAO)
Bin.Hao@fao.org

How is antimicrobial resistance (AMR) developed?

- Antimicrobial resistance happens when microorganisms (such as bacteria, fungi, viruses, and parasites) change when they are exposed to antimicrobial drugs (such as antibiotics, antifungals, antivirals, antimalarials, and anthelmintics).
- Microorganisms that develop antimicrobial resistance to several types of antimicrobials are sometimes referred to as “superbugs”.

What accelerates the emergence and spread of AMR?

- Antimicrobial resistance occurs naturally over time, usually through genetic changes.
- However, the misuse and overuse of antimicrobials is accelerating this process.

Emergence and spread of AMR in aquaculture sector

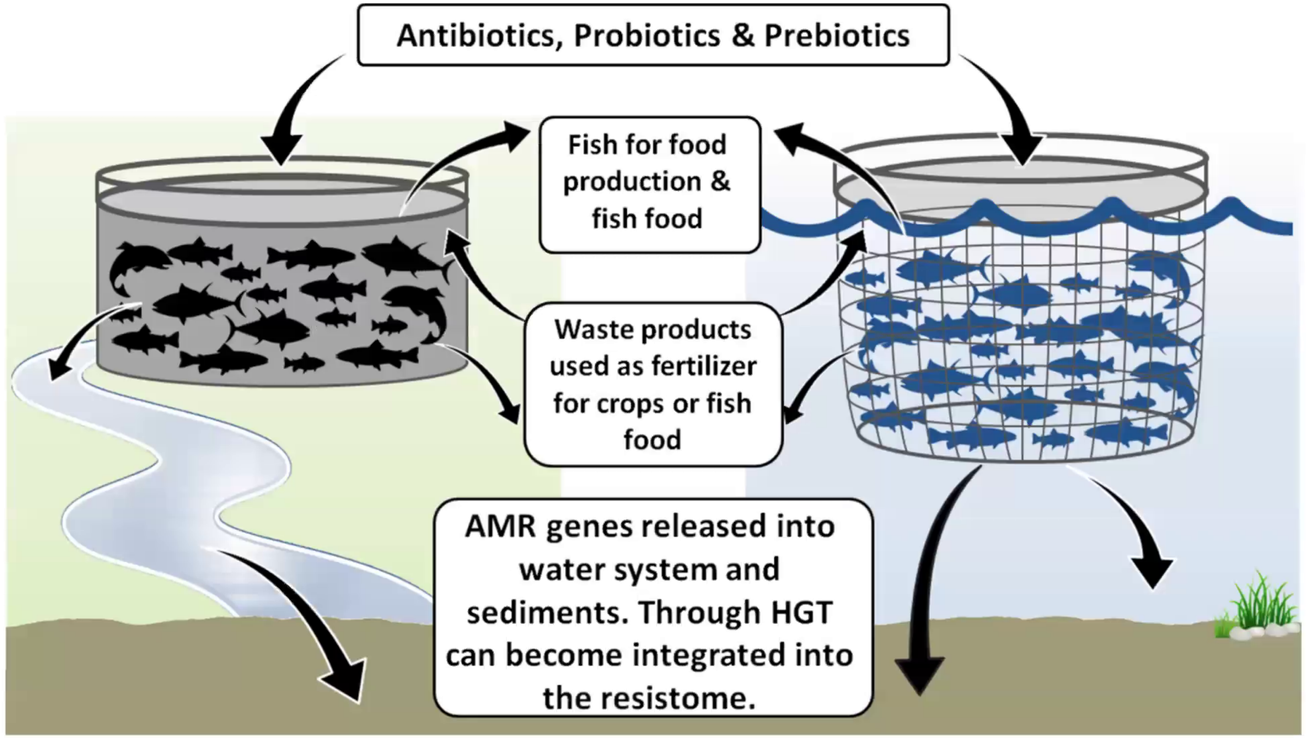
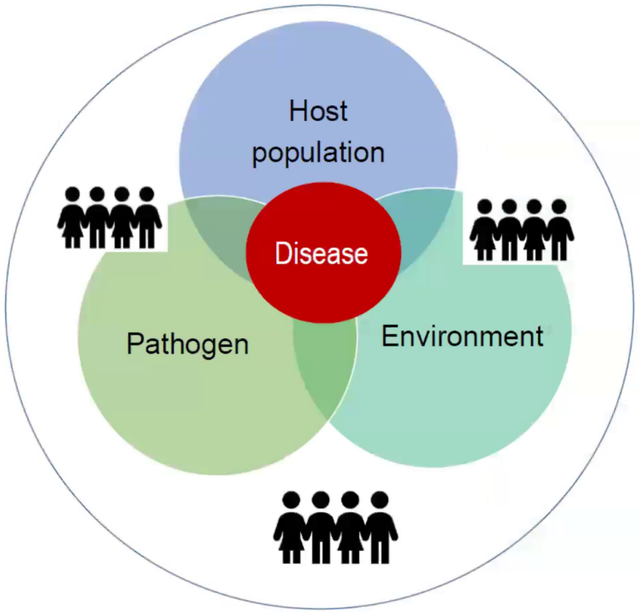
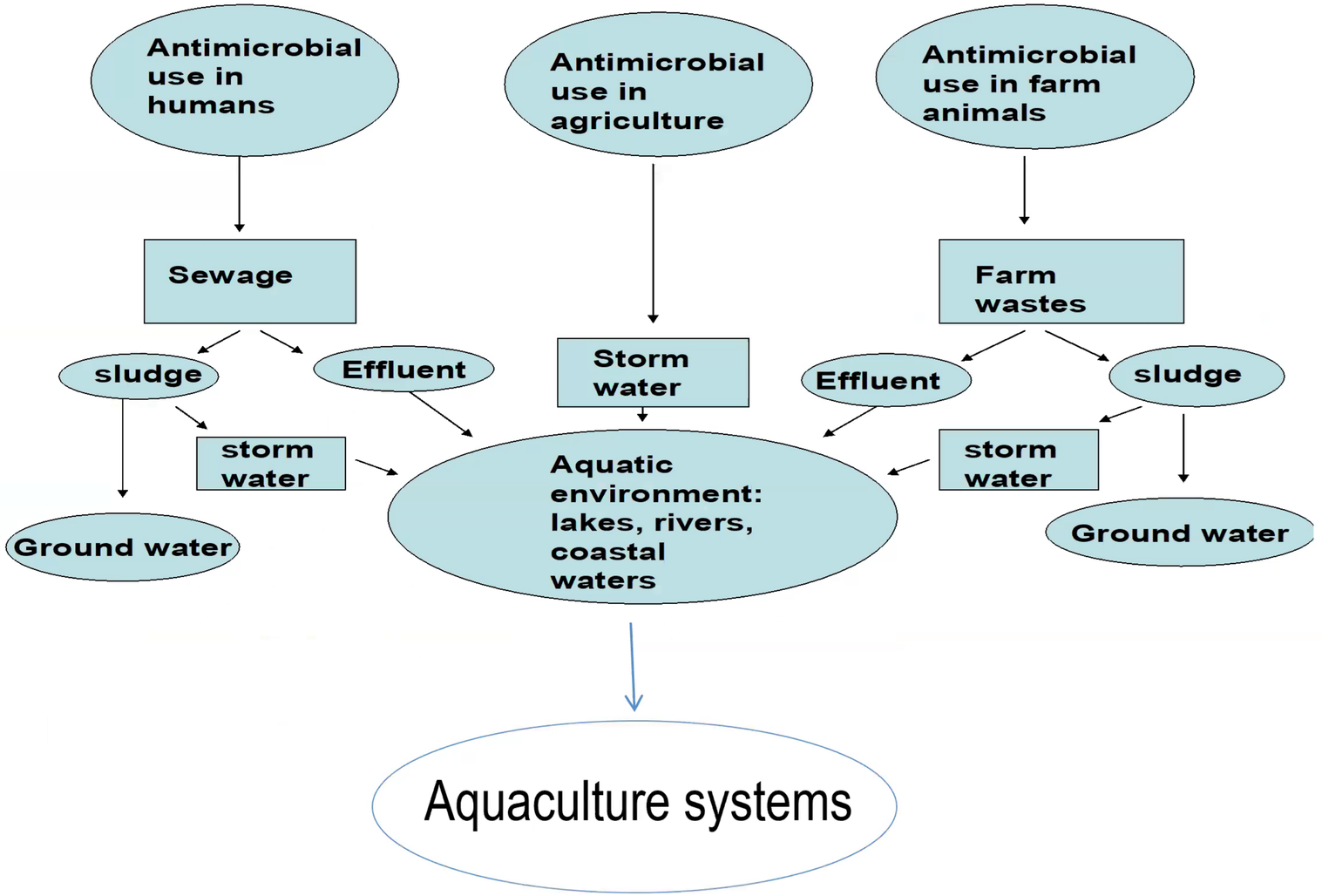


Figure 1. Pathways of antimicrobial resistance (AMR) genes from closed and open aquaculture systems into the water and sediment environmental resistome. See text for details.

Source:
Watts, Joy EM, et al. "The rising tide of antimicrobial resistance in aquaculture: sources, sinks and solutions." *Marine drugs* 15.6 (2017): 158.

Sources of AMR in the aquatic environment





Antimicrobial resistance from all sectors end up in aquatic environment

Source:
Karunasagar, I. (2012). Public health and trade impact of antimicrobial use in aquaculture. *Improving biosecurity through prudent and responsible use of veterinary medicines in aquatic food production*, 547, 1-9.

AMR detection methods in aquaculture

AMR surveillance usually conducted with culture dependent approach in aquaculture

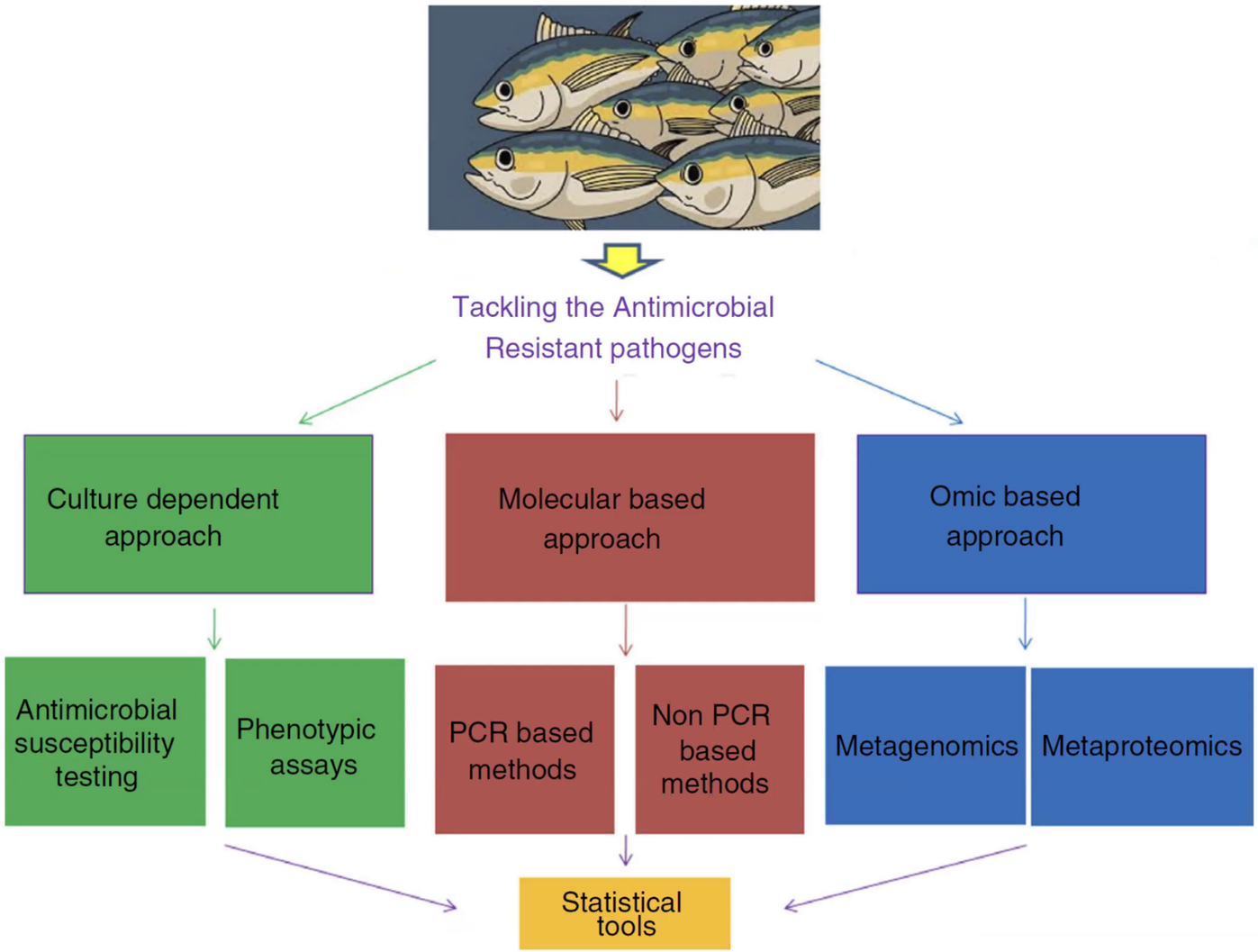


Figure 1 Different strategies for the detection of antimicrobial resistance in aquaculture [Colour figure can be viewed at wileyonlinelibrary.com]

Source:
Preena, P. G., et al. "Unravelling the menace: detection of antimicrobial resistance in aquaculture." *Letters in applied microbiology* 71.1 (2020): 26-38.

Steps in developing guidance AMR surveillance

1. Understanding and knowledge of AMU/AMR in aquaculture

2. Development of guidance
   - Review of important bacterial diseases in aquaculture
   - Review of priority diseases in tropical aquaculture
   - Prioritise the most important diseases of economically important cultured species
   - AMU/AMR survey guidance: review and assess country level applicability

Food and Agriculture Organization of the United Nations

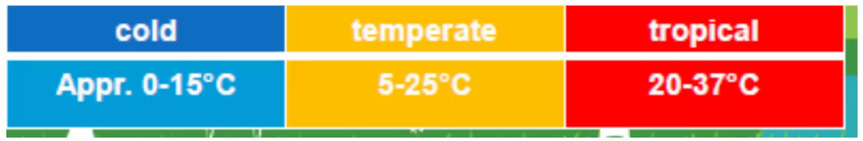
SUSTAINABLE DEVELOPMENT GOALS

FAO book: major bacterial diseases affecting aquaculture

Gram-negative bacteria	Gram-positive bacteria
Vibriosis (*V. anguillarum, V. harveyi* clade, *V. parahaemolyticus, Aliivibrio salmonicida* (*V. salmonicida*), *V. vulnificus , Photobacterium damselae)*	**Mycobacteriosis** (*Mycobacterium fortuitum, M. marinum, Nocardia asteroides, N. crassostreae (ostreae), N. seriolae)*
Aeromonasis (Motile *Aeromonas* spp.:*Aeromonas caviae, A. hydropila, A. sobria, A. veronii, A. jandaei;* *A. salmonicida)*	**Streptococcosis** (*Streptococcus agalactiae, S. iniae, Lactococcus garvieae, Aerococcus viridans)*
Edwardsiellosis (*Edwardsiella anguillarum, E. ictaluri, E. piscicida, E. tarda, Yersinia ruckeri)*	**Renibacteriosis** (*Renibacterium salmoninarum)*
Pseudomonasis (*Pseudomonas anguilliseptica, P. fluorescens)*	**Infection with Anaerobic Bacteria** (*Clostridium botulinum*, *Enterobacterium catenabacterium)*
Flavobacteriosis (*Flavobacterium branchiophilum, F. columnare, F. psychrophilum, Tenacibaculum maritinum)*	
Infection with Intracellular Bacteria (*Piscirickettsia salmonis, Hepatobacter penaei, Francisella noatunensis, Chlamydia* spp.)	

Criteria used for making the draft list of most important bacterial pathogens in aquaculture

(1) economic importance of affected species
(2) socio-economic impact
(3) zoonotic potential



In red: considered important for tropical regions

Zoonotical fish pathogenic bacteria from warmwater systems

- *Streptococcus agalactiae* (**tilapia**, a.o.)
- *Streptococcus iniae* (**tilapi**a a.o.)
- *Edwardsiella tarda* (eel, cichlids, ornamental fish)
- *Vibrio vulnificus* (eel)
- *Photobact. damselae damselae* (marine fish)
- *Mycobacterium marinum* (various warmwater fish, incl. **tilapi**a)
- *Mycobacterium fortuitum* (warmwater ornamental fish)

Preliminary guidance to survey questionnaires

Important elements in an AMR surveillance:

Data collection	Sampling design
Logistics and operational aspects	Target microorganism
Stakeholders	Laboratory methodology
Surveillance objectives	

Developed during Workshop in Mangalore India April 2017

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Preliminary guidance considerations in the conduct of AMU and AMR surveillance

1. Contact information profile	2. Farm information
3. **Types** of antimicrobial agents used in cultured species (antibiotics, external treatments, antihelminthics)	7. **Availability** of these agents (freely available, prescription)
4. **Doses** of antimicrobial agents used in cultured species, expressed in mg	8. Drug **sales**
5. **Duration** of antimicrobial agents used in cultured species, expressed in days	9. Drug sales by routes of administration (e.g. medicated feed; bath treatment; directly to the pond; etc)
6. **Effectiveness** of antimicrobial agents used in cultured species, expressed in percent	

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Preliminary guidance considerations in the conduct of AMU and AMR surveillance

1. Contact information profile	2. Farm information
3. **Types** of antimicrobial agents used in cultured species (antibiotics, external treatments, antihelminthics)	7. **Availability** of these agents (freely available, prescription)
4. **Doses** of antimicrobial agents used in cultured species, expressed in mg	8. Drug **sales**
5. **Duration** of antimicrobial agents used in cultured species, expressed in days	9. Drug sales by routes of administration (e.g. medicated feed; bath treatment; directly to the pond; etc)
6. **Effectiveness** of antimicrobial agents used in cultured species, expressed in percent	

Data collection of data (consideration)

- Antimicrobial classes included on the list are based on a previous analysis of the current known national antimicrobial resistance mechanisms.
- Nomenclature of antimicrobial agents reported should comply with international standards.
- If the report is going to be available to the public, anonymity of individual enterprises should be ensured

Logistics/operational aspects (considerations)

- Information to be collected by government officers, extension officers, academic institutions.
- Resources for survey should be made available by the authorities.
- Stakeholders: farmers, veterinarians/aquatic health professionals; associations of aquaculture producers, exporters; aquaculture extension officers; academic institutions; pharmaceutical industry, customs department; fish inspectors; government officers

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Preliminary guidance considerations in the conduct of AMU and AMR surveillance

Surveillance objectives (examples)

- Establish baseline data on AMU and AMR in country for important cultured aquatic animal species.
- Identify data gaps and research requirements.
- Conduct risk analyses as relevant to aquatic animals in a One Health approach.
- Identify appropriate interventions to control the emergence and spread of resistant bacteria including prudent use guidelines and evaluate their effectiveness.
- Provide recommendations on aquatic animal health policies and programmes.

Sampling design (considerations)

- Sampling to cover aquaculture farm animals, animals in retail, processed products.
- Random sampling to cover all aquaculture species and ecological regions with aquaculture activity in the country.
- Targeted sampling based on information on AMU.
- Samples should be representative of the AMR situation in the concerned aquaculture system and cultured fish/shrimp species.
- Continuous sampling (longitudinal) to cover seasonal and regional variations

Food and Agriculture Organization of the | SUSTAINABLE DEVELOPMENT

Preliminary guidance considerations in the conduct of AMU and AMR surveillance

Target microorganisms (considerations)

- Bacteria that are native to the aquatic environment in the ecosystem (freshwater, marine, brackish water).
- Pathogens relevant to the aquaculture species in the culture system in the country.
- Indicators of contamination coming from humans and animal farms.
- Human pathogens like *Salmonella*, if there has been an established link between the aquaculture system and outbreaks of fish poisoning.
- Number of isolates of each type to be tested based on frequency of isolation of the target microorganism and expected level of prevalence of resistance in the bacterial population.

Laboratory methodology (considerations)

- Use internationally valid methods for isolation and identification of target bacterial species (e.g. International Organization for Standardization (ISO), AOAC International, American Public Health Association).
- If such methods are not available, consider “fit for purpose” method based on performance characteristics of the method (e.g. FAO/WHO Guidance on human pathogenic *Vibrio* spp.).
- Perform disc diffusion and MIC assays as per CLSI or other internationally validated guidelines.
- Ensure laboratory quality control systems are in place. Preferably, laboratories should have accreditation (e.g. ISO 17025).
- Conclusions on sensitivity/resistance should be based on epidemiological cut-off values.
- If these values do not exist, try to establish by analyzing MIC values of required number of wild-type isolates.
- Report results providing data on resistance, MIC and zone diameter values.

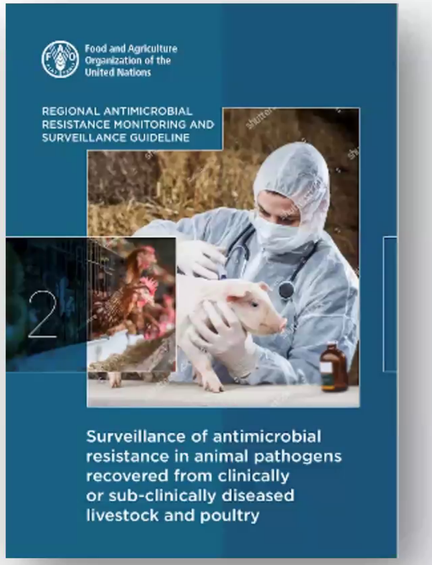
Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

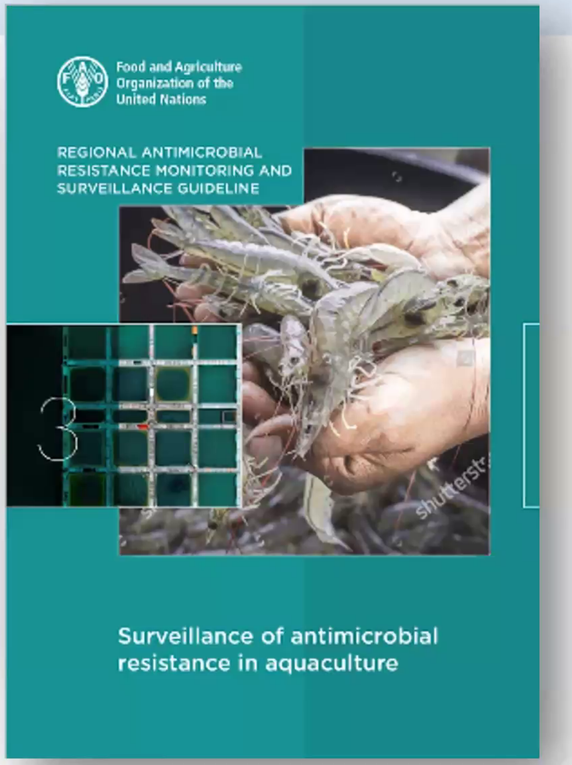
The FAO Regional Office for Asia and the Pacific (RAP)

Regional Guideline Series on antimicrobial resistance

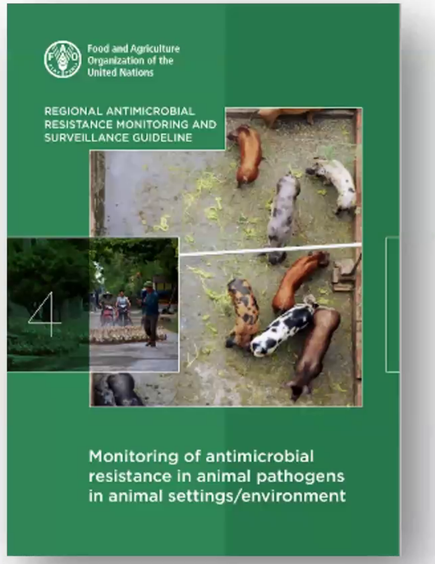
Volume 1:
AMR surveillance in bacteria from ***healthy animals***



Volume 2:
AMR surveillance in **livestock pathogens**



Volume 3:
AMR surveillance in ***aquaculture***



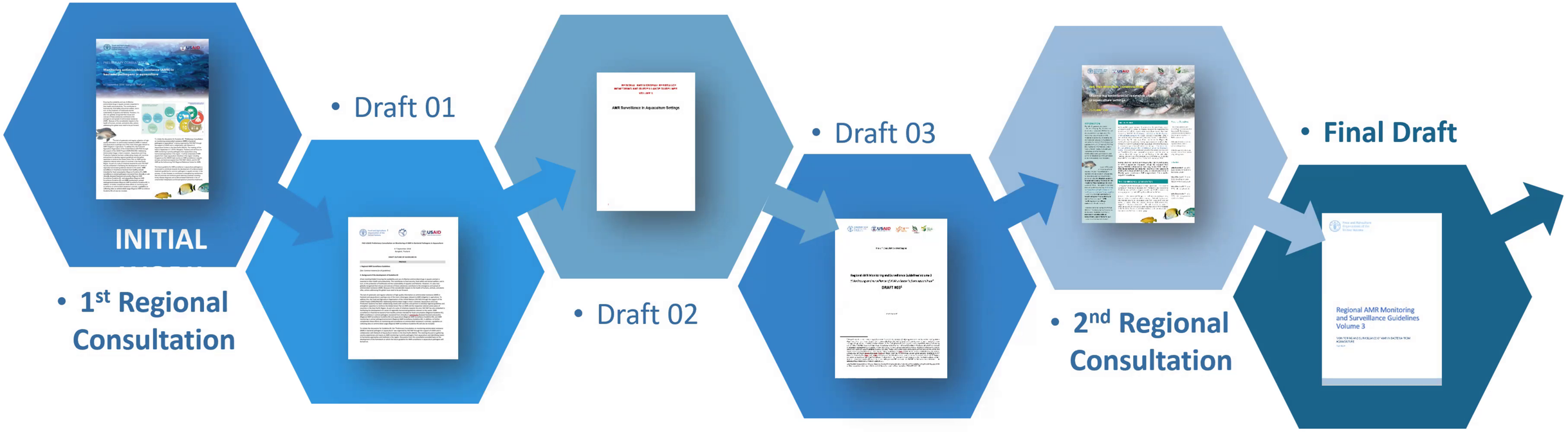
Volume 4:
Monitoring antimicrobial residues in ***animal products***

Volume 5:
Monitoring ***AMU at the farm level***

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Regional Guideline Vol 3: Development process



Regional Guideline Vol 3: Development process

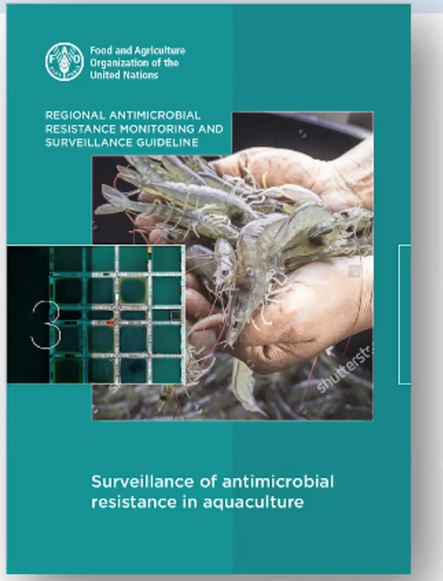
A regional product with collective inputs from:

- Country representatives and national experts in Asia
- International experts on AMR surveillance in aquaculture
- Technical partners and other international organizations
- FAO (FAO country offices, FAO RAP, FAO Headquarters, FAO Reference Centres
- *Drafting team: FAO RAP, SFA, NParks, with experts (Dr Ron Miller, Dr Peter Smith)*

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Regional Guideline Vol 3: Monitoring and surveillance of AMR in aquaculture



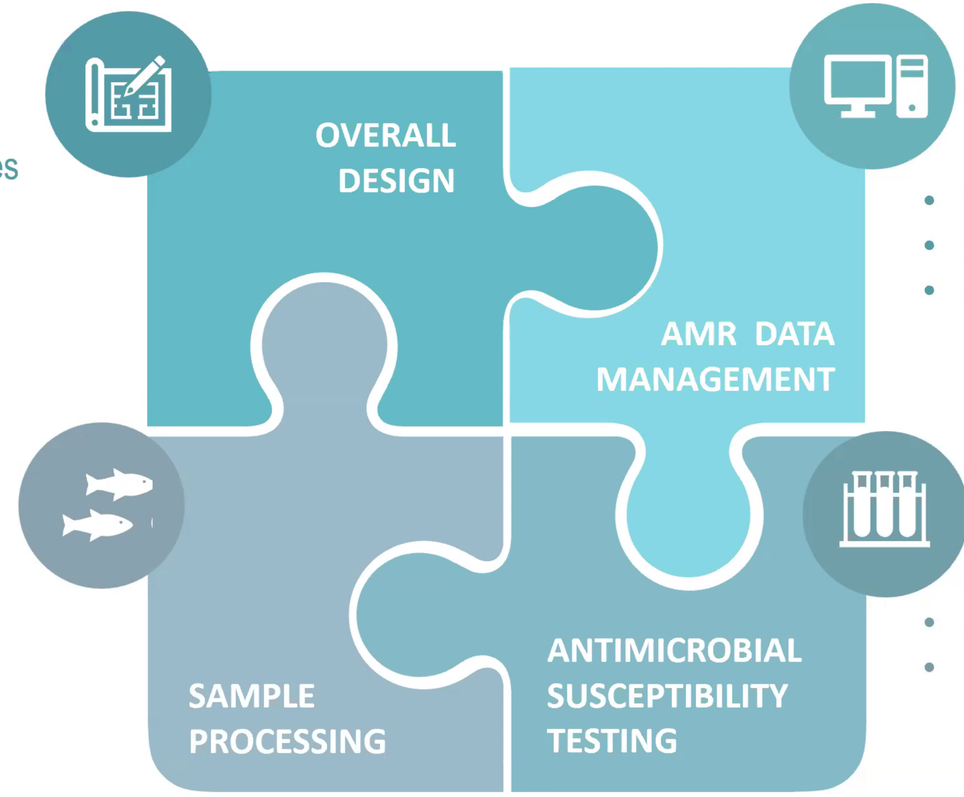
***Volume 3*:**
AMR surveillance in
aquaculture

Guidance to identify:

- AMR surveillance objectives
- Target population
- Target bacterial pathogens
- Sampling approaches

Guidance to carry out:

- Sample collection
- Transport and labelling
- Sample processing
- Bacterial isolation and ID
- Storage of isolates



Guidance on:

- Data recording and storage
- Data display
- Application of data generated

Guidance on:

AST methods based on objectives
- Antimicrobial panel development
- Interpretation of AST results

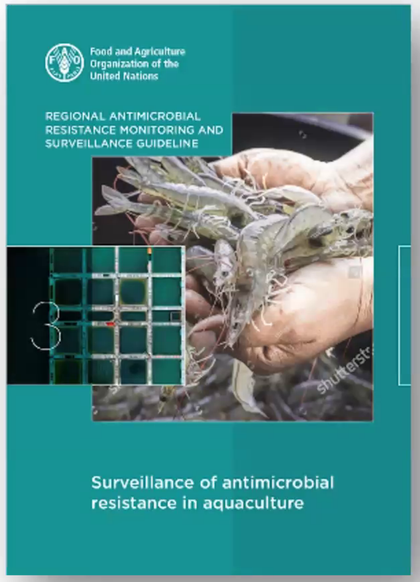
Operationalization

CONVENIENT ENTRY POINTS FOR INITIATION

(Note: This is mainly to trigger surveillance initiatives; findings should not be extended to the population and must be interpreted with caution)

TARGETS FOR REGIONAL HARMONIZATION

These may be integrated in the planning and design at the outset, or progressively over time as the country progresses in its routine AMR surveillance.



Volume 3:
AMR surveillance in
aquaculture

AMR data are obtained from bacteria from the most accessible population of animals.

TARGET POPULATION

AMR data in bacteria are obtained from the target aquaculture population, as prioritized by the country based on the objectives set for the AMR surveillance in aquaculture.

AMR data are obtained from a any number of samples and based on accessibility to these aquatic animal species. *Data obtained cannot be extended to the population of interest and should be limited to the samples tested. Information may be used as basis for planning an expanded surveillance plan*

SAMPLING STRATEGY

Takes into account both the epidemiologic (e.g., representativeness) and biologic (e.g., type of sample, timing) considerations, as well as the feasibility of logistical support for implementation.

Any bacterial pathogen that the current laboratory capacity can handle, *but consider the context from which the isolates were obtained from.* If able, this can be extended to any of the three regional priorities (*Aeromonas* spp., *Streptococcus* spp., *Vibrio* spp.) considering the available resources and capacity.

TARGET BACTERIA

Obtained from an operational aquatic disease surveillance programme and includes bacteria considered as national priority based on prevalence of disease, outbreak frequency, economic impact, number of potential host, or for its impact on AMU.

Qualitative data are obtained through disk diffusion method with or without consideration for international standards. *Value and validity of resulting data may be compromised and will have limited use for an AMR surveillance programme.*

TYPE OF DATA GENERATED

Internationally accepted standard methods is used whenever they are available and appropriate.

A few select antimicrobials are included in the panel. The appropriate highest priority critically important antimicrobials are preferred.

PANEL OF ANTIMICROBIALS

The core panel of antimicrobials monitored includes specific priorities and needs of the country, with consideration for harmonization with the regional antimicrobial panel as well.

REGIONALLY HARMONIZED AMR SURVEILLANCE

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

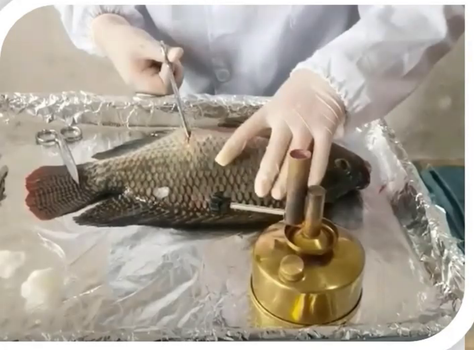
Virtual Training Course on Surveillance and Monitoring of Antimicrobial Resistance in Aquaculture

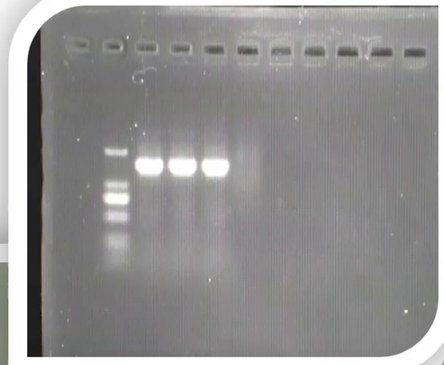
26-30 July 2021, virtual event

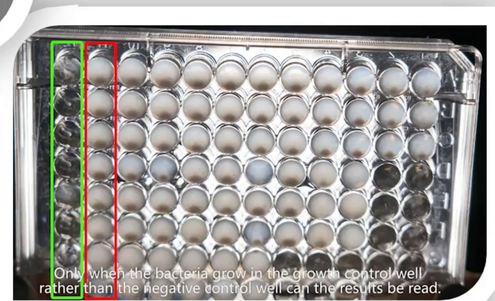
This training course was organized by FAO in collaboration with the Institute of Hydrobiology of Chinese Academy of Sciences (IHB-CAS), and INFOFISH, with auspices of TCP/RAS/3702: Support Mitigation of Antimicrobial Resistance Risk Associated with Aquaculture in Asia

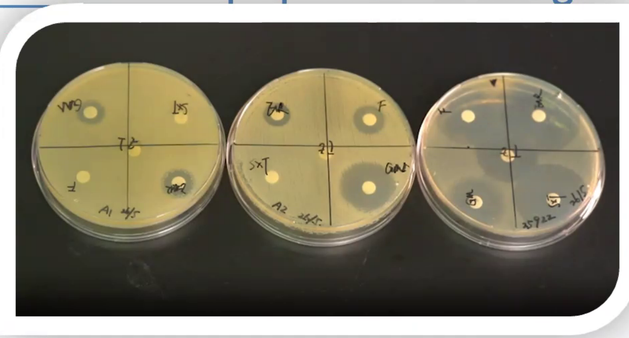
No. of participants: 245 from 46 countries

Presentations and videos could be accessed by the link: http://infofish.org/APFIC/index.php/amr-training









Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Other ongoing and future initiatives at FAO RAP linked to this Regional Guideline Vol 3

Development of regionally-customized broth microdilution plates

AMR data management templates and platform

Setting up of Lab coordination network

Development of training materials

In-country pilot initiatives

Key messages

- First step is to understand what bacterial diseases are affecting aquaculture and to determine how they are being managed, i.e. treatment with antibiotics or good biosecurity/good husbandry
- Second step is to conduct an AMU survey and this is a prerequisite to AMR surveillance
- Step-wise implementation guidance is needed
- Capacity building for non-specialists (non-epidemiologist) needed
- Any surveillance activity in the aquaculture sector needs to find its place in the One Health platform
- In the future, an integrated surveillance of all relevant sectors will help better understand AMR

Key messages

- Surveillance is an economic activity and government commitment is essential.
- Projects may be able to provide the start-up costs in terms of training, however, the governments need commitment and to find resources for its implementation
- It requires significant financial support, not usually easily available and mobilized, in developing countries.
- Combined principle of co-financing, international support and national commitment is necessary
- In terms of knowledge, it is important to have a clear understanding of AMU in aquaculture, how it is being managed, i.e. antibiotic treatment or others, development of AMR, risk of AMR in aquaculture and how AMR surveillance can support the risk analysis process.

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

Key message: Understanding and avoiding the threat (Smith, 2017)

Understanding the threat	Avoiding the threat
Which bacterial pathogens for which species?	If we wish to avoid re-entering the pre-antibiotic age we must learn how to use antibiotics wisely
How are these bacterial diseases being prevented/managed? Good husbandry, vaccines, antibiotics, other alternatives?	Although we have very little idea about how much we use in aquaculture we do know that we must use less.
Source attribution of AMR in aquaculture associated bacteria is very complex and caution needs to be exercised in interpretation of data. Mere detection of AMR in aquaculture systems does not imply misuse of antimicrobials in aquaculture.	We need antibiotics but we must learn to use antibiotics only when that use is necessary, prudent and rational.
Is there a direct link between the resistance profile and AMU. AMR may be naturally present in the aquatic environment or derived from AMU in other sectors or derived from AMU in aquaculture	When we use antibiotics, we must learn the most effective and efficient method to administer them.

Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

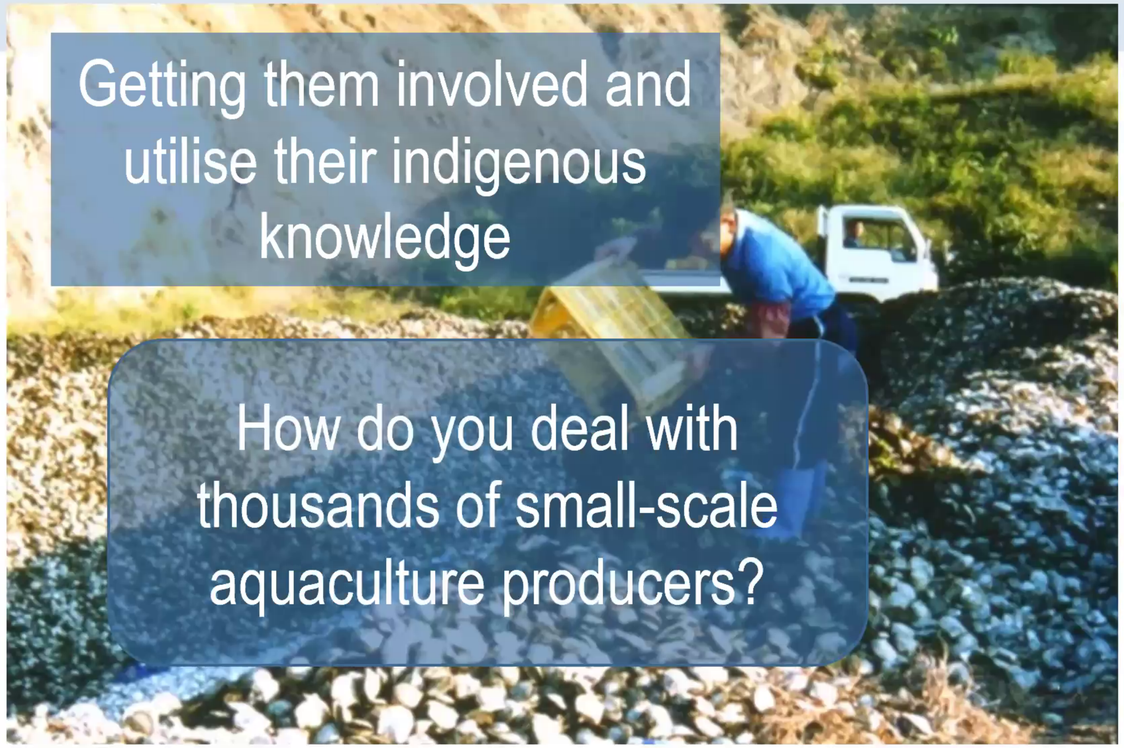
Key message: Important role of farmers

Disease costs are too high for small-scale sector to survive

Understanding their needs and expectations

Andy Derwent with oysters hit by the mystery organism in Georges River Picture: GRANT TURNER

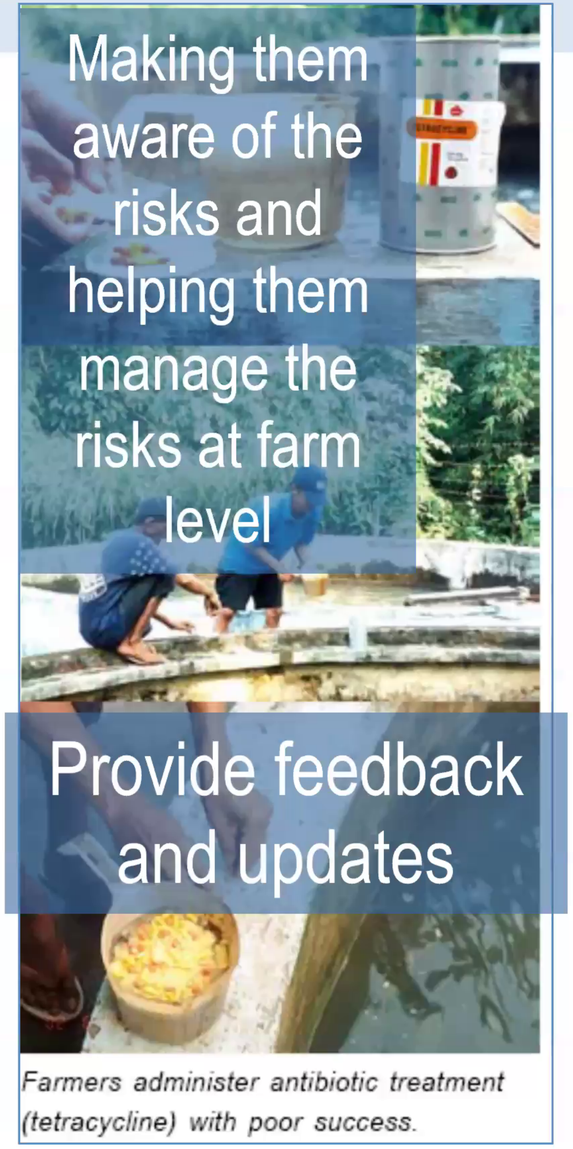
Farmers suffer as bug wipes out oysters



Getting them involved and utilise their indigenous knowledge

How do you deal with thousands of small-scale aquaculture producers?

Effective technologies and strategies which are accessible and affordable to the resource-poor small-scale sector



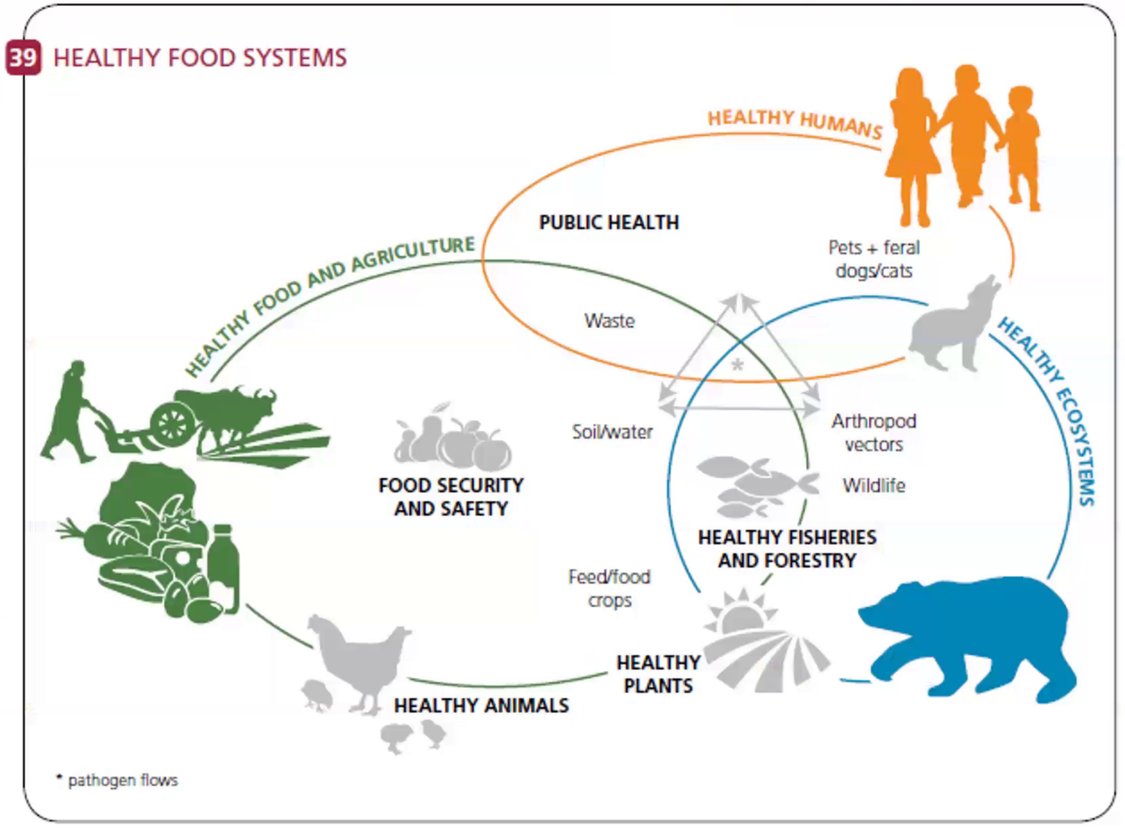
Making them aware of the risks and helping them manage the risks at farm level

Provide feedback and updates

Farmers administer antibiotic treatment (tetracycline) with poor success.

Key message: Better understanding, coordinated and integrated actions

- Aquaculture biosecurity and AMR may be complex & are driven by many interconnected factors.
- Single, isolated interventions have limited impact.
- Greater innovation, research and investment are required in surveillance, MRLs, new antimicrobials, vaccines for low value species, other alternatives to antimicrobials and diagnostic tools.
- Aquaculture producing countries need to develop the aquaculture component, integrate to country NAPs
- We need to continue to better understand AMR in aquaculture and its coordinated integration into One Health



Risk and impact assessment, AMU survey, AMR surveillance and monitoring, farmer behavioural change – they all go together

FAO will be happy to work with Members (on request) and collaborate with interested partners within the framework of the FAO Action Plan on AMR coherent with the WHO Global Action Plan on AMR, quadripartite WHO/FAO/WOAH/UNEP and One Health

Thank you very much for your kind attention.

Bin Hao
Fishery Officer, Food Safey, Nutrition and Health Team
Food and Agriculture Organization of the United Nations (FAO)
Bin.Hao@fao.org