Ministry of Foreign Affairs

Opportunities to improve quality of exports of Indian Seafood

Commissioned by the Netherlands Enterprise Agency

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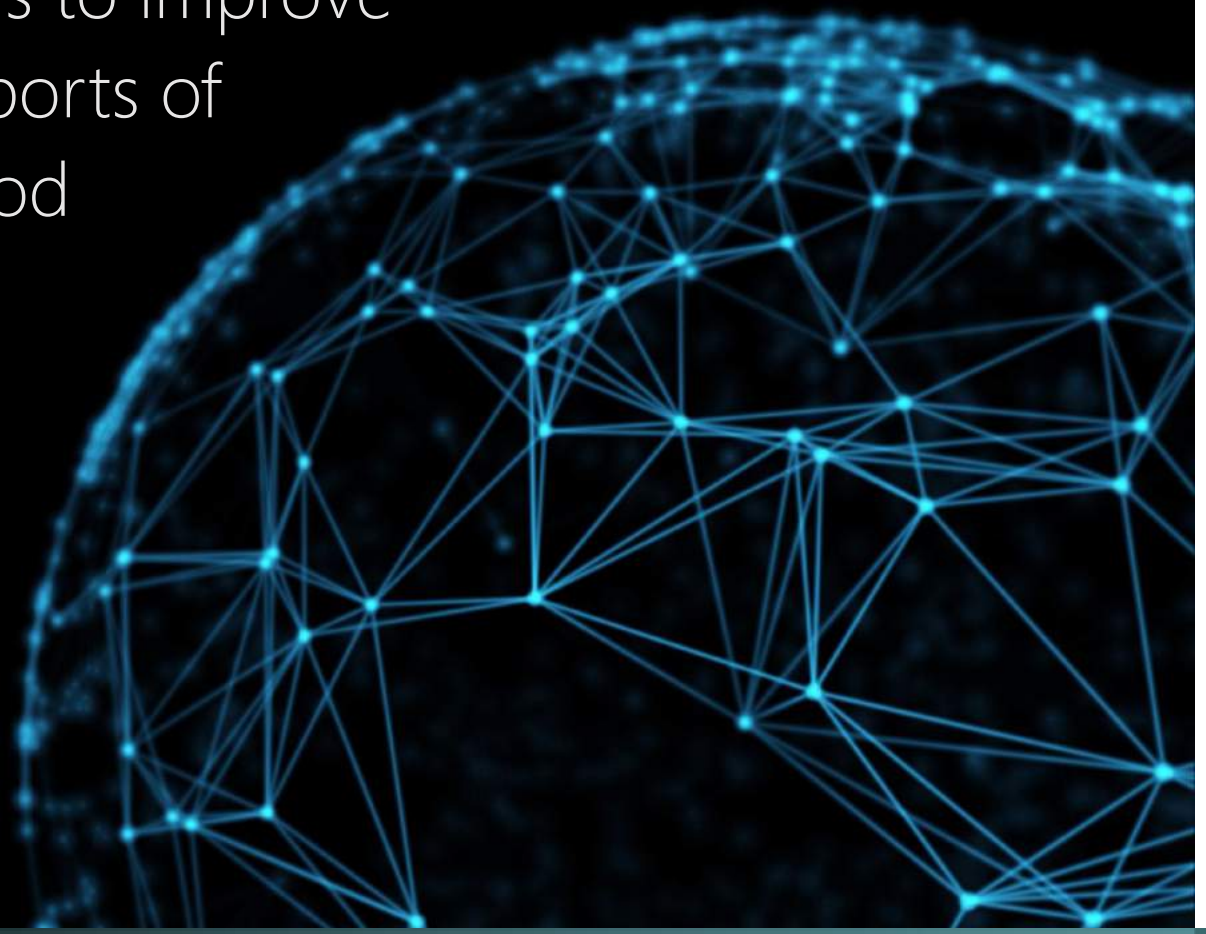
Opportunities to improve quality of exports of Indian Seafood



NBSO India | Netherlands Business Support Office

Ministry of Foreign Affairs of the Netherlands

SUSTAINABLE AQUACULTURE SOLUTIONS

Solidaridad

Time to re-think AMR

FROM MORE TO BETTER

Dr. Ir. Karin van de Braak

October 2021

Preface

When I started my career over 25 years ago, I travelled to India to discuss antibiotic use in aquaculture. During workshops with shrimp farmers and associations, it was explained that antibiotics are not needed in aquaculture and how more focus should be addressed on disease prevention. In the meantime, aquaculture production worldwide, and in India in particular, significantly increased, there is much more experience and better knowledge on production. However, with increased production, problems with diseases also significantly increased and the AMR problems are greater than ever before.

It is without any doubt that, with business as usual, new diseases will evolve and that problems with AMR will further increase. Furthermore, AMR is linked with other global challenges and for most of them limits are reached. Therefore, it is time to rethink the way we address diseases and AMR in aquaculture (and beyond!). It must and can be done differently by understanding the root causes of our problems and applying a systemic approach. We are allowed to switch our focus from control of diseases and AMR – towards creating resilient production areas.

With this study on AMR, I would like to highlight how The Netherlands can take a leading role in the transformation of the Indian seafood sector towards a healthy production sector by a systemic approach, back in balance with nature.

Dr. Karin van de Braak

Sustainable Aquaculture Solutions

Executive Summary

Antimicrobial resistance (AMR) is a major global threat to human and animal health and growing at an alarming rate.

This study was commissioned by the Agriculture Department of the Embassy of the Kingdom of the Netherlands in New Delhi, the Netherlands Business Support Office (NBSO) in Hyderabad and supported by the Netherlands Enterprise Agency (RVO). The aim of this study was to investigate the importance of AMR and to identify opportunities where Dutch parties can contribute with knowledge, technical assistance and technology and experience to address drug-resistance in the Indian seafood sector.

The first part of this report describes developments in the aquaculture sector. Disease outbreaks are recognized as a major constraint to aquaculture production and trade and are affecting economic development of the sector in many countries of the world. This is also the case for the shrimp culture sub-sector in India. The importance of understanding disease outbreaks is explained with the iceberg model. Diseases are only the tip of the iceberg and often addressed in a linear, problem-solving approach.

However, fish and shrimp diseases are complex problems and occur as a combination of suboptimum factors within the host, microbes and the environment. Complex problems are never solved by focusing on the problem itself. In many cases the situation will get worse!

The actual causes are hidden from plain sight, especially with diseases in aquaculture. For a real transformation, the environmental and social structures of the system need to be considered as well.

AMR in aquaculture is growing by tending to address diseases in a problem-solving approach. However, AMR is an extremely broad and complex problem, interrelated with other sectors. Part 2 of the report explains the linkages between AMR and other major global challenges and outlines 3 approaches; 1. Control of diseases and AMR; 2, Sustainable intensification and 3. Nature-positive systems. These different approaches complement each other and already co-exist, with importance in the order they are presented.

Executive Summary

Each of the approaches has advantages and significant disadvantages, which need to be considered in selection of the options.

The 1st approach focusses on control and results in more knowledge and awareness of diseases, diagnostics, responsible treatment and trends and harm of AMR. The advantage is that a lot of knowledge is generated. The disadvantages of this reactive approach are that it is complicated and costly; the disease losses already occurred, new diseases will certainly emerge and AMR and even multi-drug resistance will make things worse.

Approach 2 is focusing on disease prevention by creating efficient production systems and a healthy culture environment, aiming at zero-use of antibiotics. The advantage is a high production output per input factor. However, the focus on intensification and efficiency of the level of the production systems alone may lose sight of the other global challenges of today, such as climate change, biodiversity loss and increasing inequalities.

The 3rd approach in this report is on creating nature-positive and resilient production areas with regenerative systems and fair price for the farmers. The important advantage is that other major global problems are addressed in this way as well. The disadvantage of this approach, however, is that it is complex, many partners are involved and sometimes requires high transition costs or reduced income at start.

This section includes examples of each of the different approaches defined in this report.

Part 3 of this report includes the recommendations and starts with an overview of Dutch parties which could contribute to each of the different areas. It takes the SDG's into account along the shrimp production and supply chain in India with exports to The Netherlands. The needs and advantage of the system approach are further explained. Only reducing the negative aspects is not enough anymore. The regenerative approach creates potential emerging positive synergies along environmental, social and financial aspects.

Key messages (1/2)

- Aquaculture production and seafood exports from India to EU/NL will significantly increase in the coming decade
- Fish and shrimp production intensification will result in emerging diseases and more outbreaks and losses, increased antimicrobial use and more antimicrobial resistance (AMR) problems
- AMR is recognized as a silent pandemic, with the potential to cause huge social and economic disruption
- AMR is a major global problem and strongly interlinked with other global problems, such as climate change, biodiversity loss and social inequalities
- India is among the countries with the highest levels of clinical and aquaculture multi-antimicrobial resistance and is among the ones exposed to the highest climatic vulnerability and temperatures rises
- This study emphasizes the need for urgent coordinated effective national and international interventions and multi-sectoral collaboration to limit antimicrobial use and the global spread of AMR
- Accountability extends beyond national borders and The Netherlands, as a major importer and with extensive experience in intensive animal production, can contribute to the development of the Indian seafood sector which goes beyond sustainability

Key messages (2/2)

- The complex nature of AMR requires a holistic and integrated approach and is, in this study, divided in;
    1. Control of diseases and AMR: More knowledge and awareness in AMR, disease diagnostics & responsible disease treatment
    2. Sustainable intensification; More focus on disease prevention by creating efficient culture systems and a healthy environment
    3. Creating nature-positive and resilient production areas with regenerative systems and fair price for the farmers
- The goal is no longer a focus only on increasing production and efficiency (which may increase the problems), but to take a systemic approach to transformation and returning the ecological balance
- Regenerative aquaculture has the potential to create a synergistic relationship between ecological, social and economic systems and should be prioritized; in this way antimicrobial use is addressed at the base with healthy production systems in an area; it is much easier, cheaper, faster and thus, more effective than to solving problems afterwards

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PART I

Introduction

Background

This research is conducted on behalf of the Netherlands Business Support Office, Hyderabad and the Dutch Embassy in India. The Dutch government underscored the importance and urgency of addressing the growing global threat of antimicrobial resistance (AMR) in all countries through a coordinated, multisectoral, One Health approach in the context of the 2030 Agenda for Sustainable Development.

The aim of this research was to provide a business case for technologies that could help reduce AMR in India, and support sustainable and responsible growth of the Indian aquaculture sector.

Results are obtained through extensive desk research of scientific and secondary research papers, global developments and stakeholder interviews. On-site, Solidaridad India conducted a field study through interviews with key-stakeholders and a survey among shrimp farmers. Other studies were conducted by major producers and exporters in the sector. The preliminary results were discussed between major Indian stakeholders and the Dutch aquaculture experts and business sector on October 1, 2021.

At the time of research and writing, COVID-19 continued to have a major impact on lives and livelihoods around the world. It shows the scale of the systemic risks we face and the lack of resilience built into our current operating models. AMR has the potential to cause an even bigger impact if we continue with business as usual. Therefore, this report explains the importance of understanding disease problems and why these are occurring. It explains the AMR linkages with other global challenges and the role that aquaculture could play in addressing these. It is suggested to focus on a value case rather than on a business case.

Objectives of this study

- Insights on the aquaculture production sector and value chain in India with trends and challenges in export to Europe/NL related to AMR
- Provide details to Dutch agribusiness to elevate the aquaculture sector in India through investments and/or knowledge and technology
- Provide insight and pave the way for Government 2 Government (G2G) or Knowledge 2 Knowledge (K2K) interventions to relevant chain actors in India
- Discuss possibilities for cooperation and business development between Indian and Dutch entrepreneurs in the seafood supply chain and beyond

Antimicrobial Resistance (AMR)

AMR occurs when bacteria, viruses, fungi, and parasites change over time and stop responding to antimicrobials that are supposed to treat diseases. The problem is huge and rapid and effective action is needed.

This study has a focus on the seafood sector in India, however, AMR is a global multi-sector, multifaceted and multi-stakeholder challenge. Antimicrobial abuse and misuse, poor hygiene and biosecurity, the enormous amounts of waste and pollution, contamination through hospitals and pharmaceutical industry, climate change and globalisation are all factors contributing to the rising rates of AMR in the world.

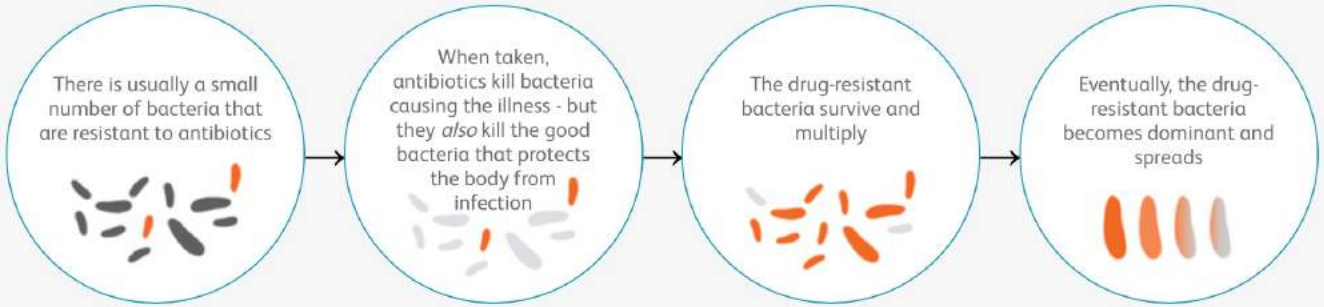
Antimicrobial resistance (AMR) develops when bacteria, fungi or viruses are exposed to antibiotics, antifungals or antivirals

As a result, the antimicrobials become ineffective, infections may persist and become increasingly difficult to control

What is antimicrobial resistance (AMR)?

Antimicrobial resistance is the ability of microorganisms (such as bacteria, fungi, viruses, or protozoa) to **nullify the effects of antimicrobial drugs**, resulting in these drugs becoming ineffective[1,2] AMR can affect anyone, of any age, in any country.

How does it happen?



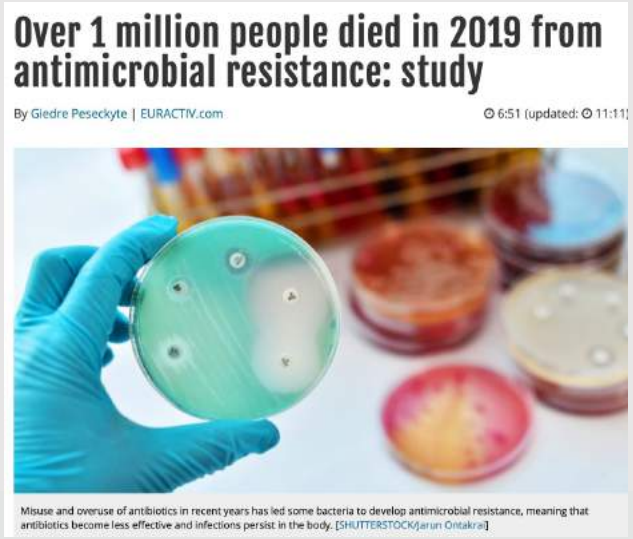
SOURCE: The Center for Disease Control (CDC)

1. Antimicrobial Resistance Fact Sheet. WHO. http://www.who.int/mediacentre/factsheets/fs194/en/
2. About Antimicrobial Resistance. CDC. https://www.cdc.gov/drugresistance/about.html

Antimicrobial resistance

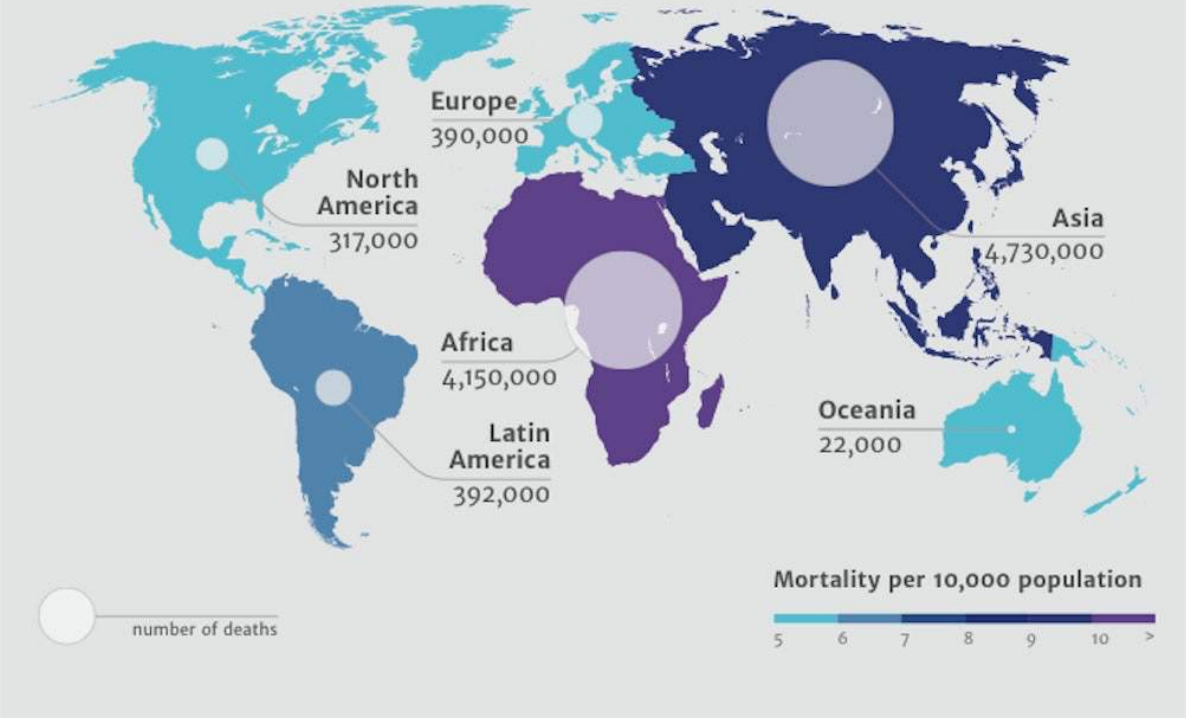
1. Is a global threat which can affect everyone in every place on earth
2. Is a hidden threat and often not recognised
3. Is on the rise and may become the leading cause of death
4. Can not be banned and will always deserve attention
5. Demands for different solutions

Source: AMR Insights


Over 1 million people died in 2019 from antimicrobial resistance: study
By Giedre Peseckyte | EURACTIV.com
Misuse and overuse of antibiotics in recent years has led some bacteria to develop antimicrobial resistance, meaning that antibiotics become less effective and infections persist in the body. [SHUTTERSTOCK/Jarun Ontakrai]


IMPACT
A continued rise in resistance by 2050 would lead to 10 million deaths and a reduction of 2% to 3.5% in GDP.
Source: O'Neill (2014) 'Review on Antimicrobial Resistance. Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations


Combating
antibiotic resistance,
a global threat

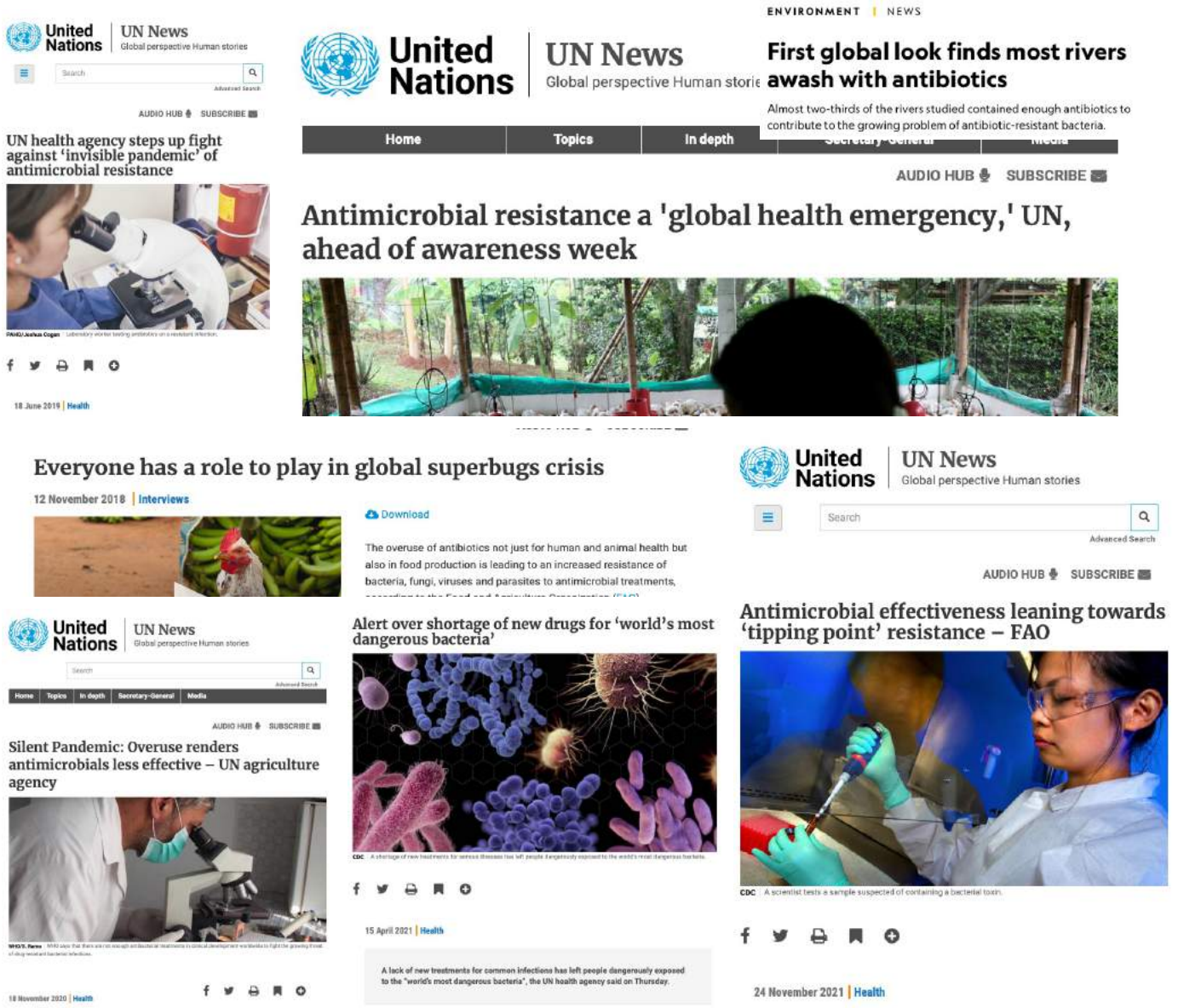

Europe
390,000
North America
317,000
Asia
4,730,000
Africa
4,150,000
Oceania
22,000
Latin America
392,000
number of deaths
Mortality per 10,000 population
5 6 7 8 9 10 >


US$
700
The median overall extra cost to treat a resistant bacterial infection
442
days
of work
The time a rural male casual worker in India has to work to earn this amount
Sujith Chandy, 'Antibiotic Use & Resistance: Patterns, Perceptions, Policy and the Price to Pay' (2014)
Dag Hammarskjöld Foundation
ReAct

We may soon reach "a tipping point" when antimicrobial resistance (AMR) becomes the leading cause of death – surpassing heart disease and other so-called lifestyle illnesses

It is estimated that each year, 700,000 people die from AMR-related causes and FAO Chief Veterinary Officer Keith Sumption said that if no actions are taken, the annual tally could soar to some 10 million by 2050

FAO, Wednesday, November 24, 2021



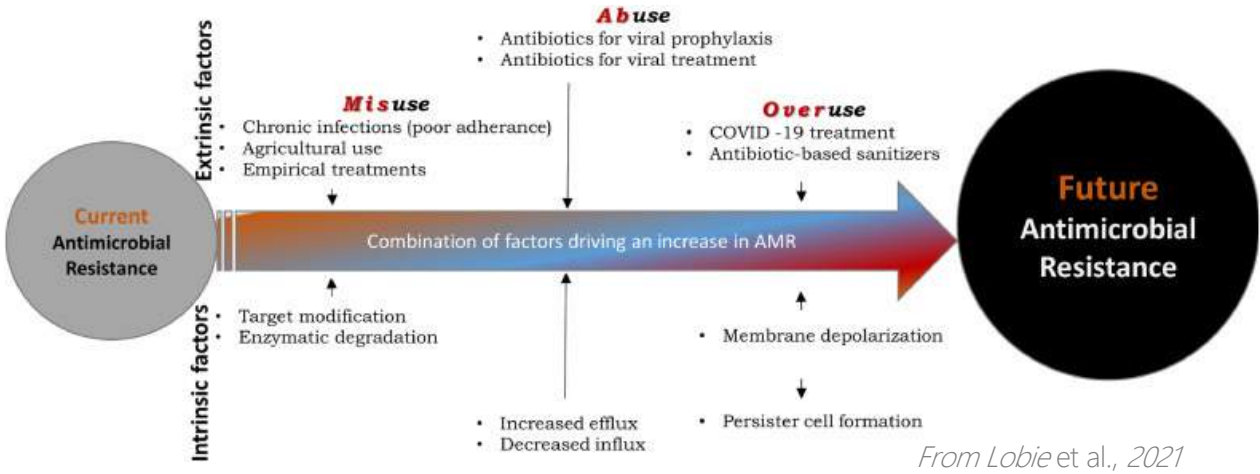
The main drivers of AMR

AMR problems accelerate due to the inappropriate use of antimicrobial agents for clinical and non-clinical applications in human health, animal health, food-animal production and crop production

Exposure of microbes to disinfectants and non-pharmaceutical agents also contributes to the microbial ability to evolve mechanisms that increase AMR

Furthermore, the environment plays a significant role: waste from farms, factories, community and healthcare settings contributing to the emergence and spread of AMR through environmental routes

It is expected that disruption of health service provision due to Covid-19 contributes to emergence and spread of AMR as well



From Lobie et al., *2021*

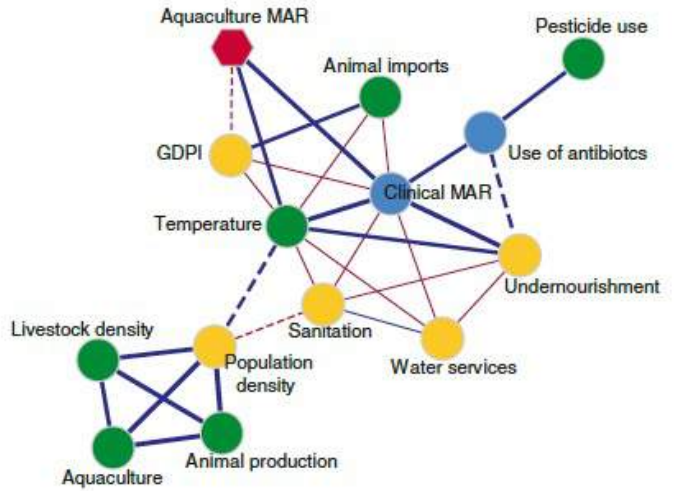
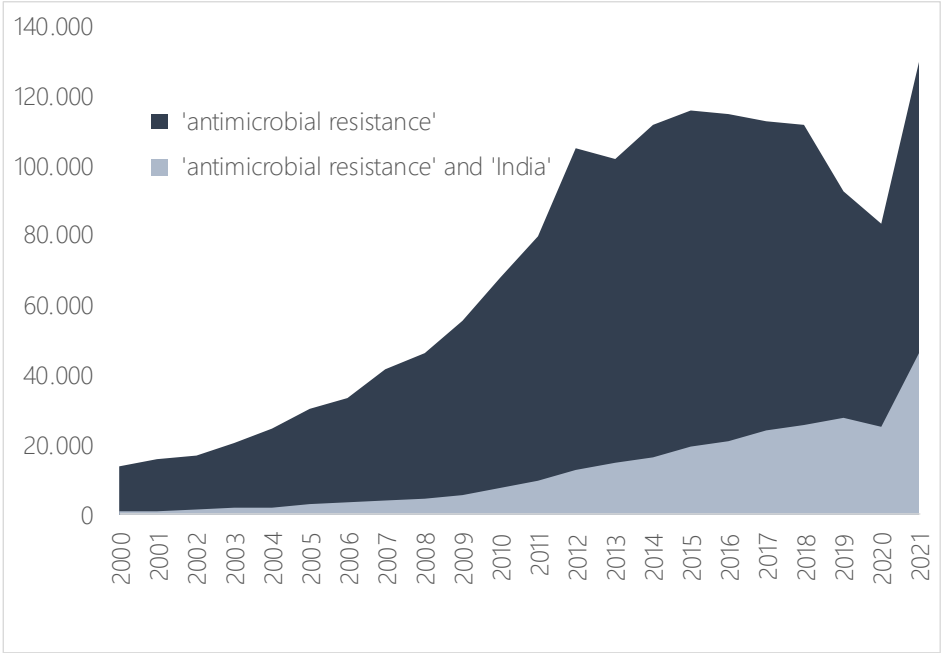


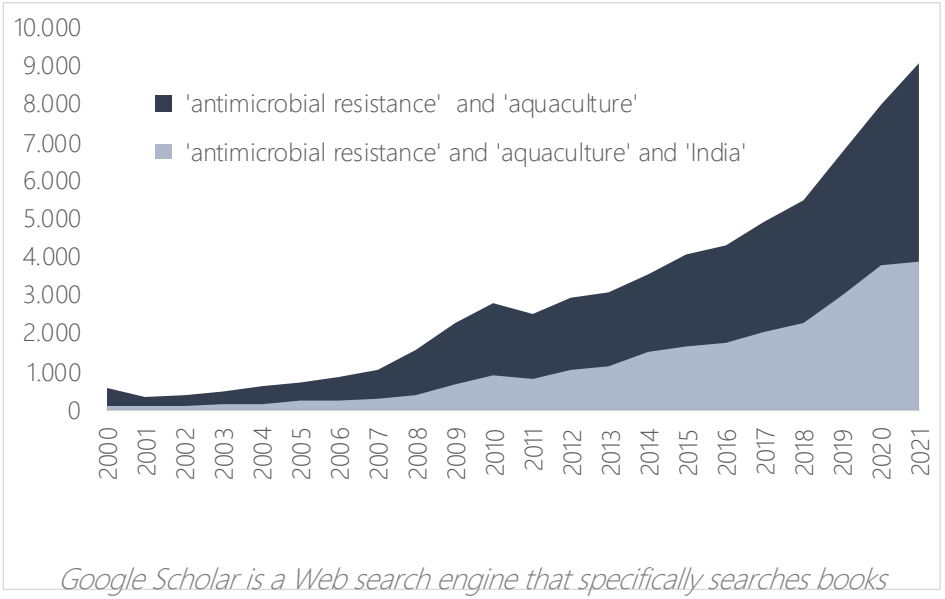
Fig. 4 Pearson correlation network between all the simple studied variables. Significant correlations (*P*-value < 0.05) are displayed with solid lines, whereas correlations ($r > 0.30$) nearing statistical significance ($0.10 > P\text{-value} > 0.05$) are shown in dashed lines. Edge weight is proportional to the correlation coefficient (r), with line width increasing with higher correlation values.

From Reverter et al., *2020*

Available information

Number of results with different search areas in **Google Scholar** shows enormous and rapidly increasing amount of information available related to 'antimicrobial resistance' and 'aquaculture' and 'India'.





Google Scholar is a Web search engine that specifically searches books articles and documents in scholarly literature and academic resources

The longer we wait the harder it gets

The problems will get bigger and BIGGER

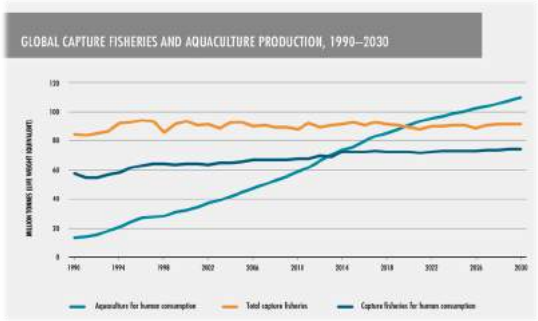
an effective approach is MORE and MORE difficult

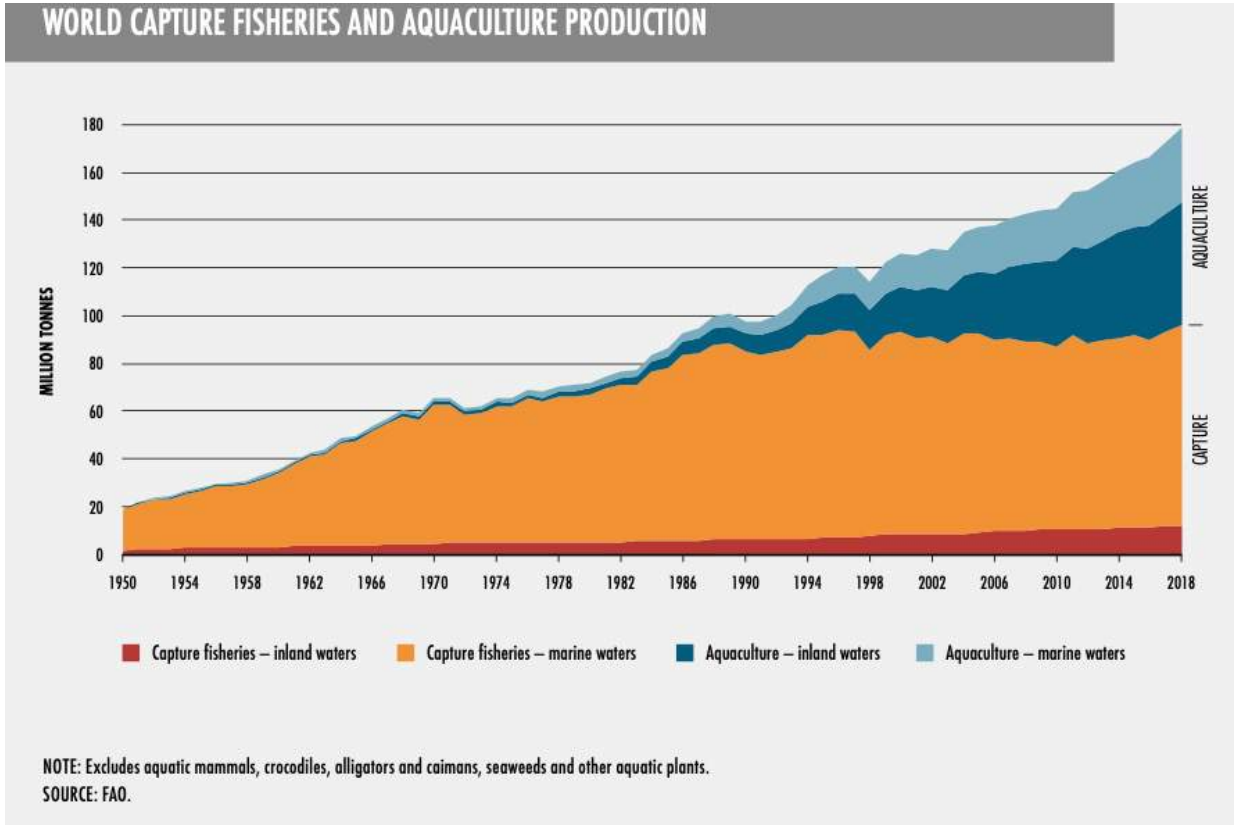
and will get MUCH more expensive

..the longer we postpone it

World Aquaculture

World Aquaculture Production





The fastest growing food production industry over the last five decades

Expected to continue this growth in the next decade

Intense debates about sustainability

Wide variety of species and production systems

World Aquaculture Growth

As new technologies and species develop, aquaculture will grow within new and existing geographies

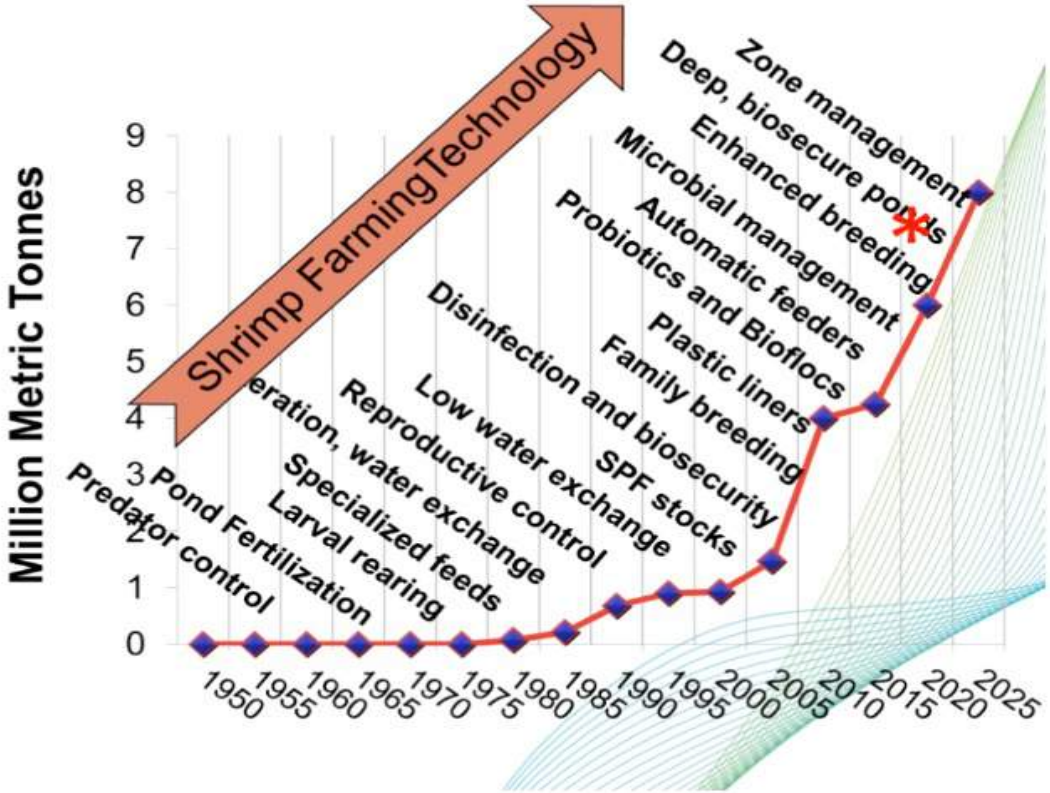
Projected growth India is +12% in 2030

World Shrimp Production

Fig. 1: Shrimp farming production by region. Sources: FAO (2019) and GOAL surveys (2011 to 2018) for 2010 to 2017; GOAL survey (2019) for 2018 to 2021.

Most popular seafood product | Strong global growth (up to 10% expected in 2021) | Expected to continue to grow | One of the most valuable species | Volatile market and prices

Trends & Developments



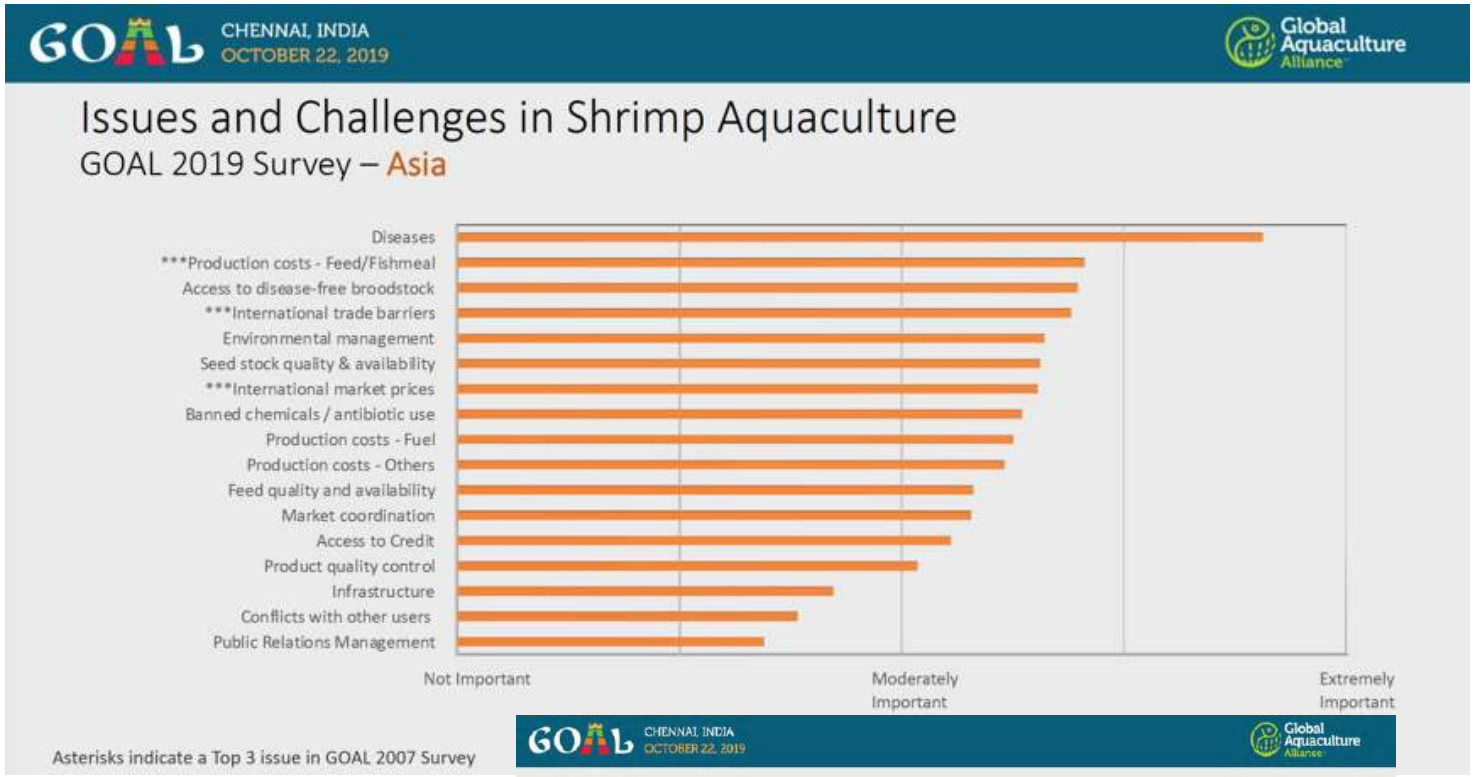
- Best Management practices
- Sustainability certification
- Fishmeal replacement
- System design
- Multi-trophic aquaculture
- Integrated systems
- Indoor RAS technology
- Regenerative aquaculture
- …

Shrimp important in global seafood trade

Wide variety of production systems | 3 main species produced | 1 species *(P. vannamei)* accounts for 77% of production | Diseases major constraint for growth | Billions of dollars lost due to diseases

Major Challenges - Diseases

Survey carried out among key players in the sector in 2019



With increasing production, more diseases will evolve

The biggest problems experienced by the growth of the global aquaculture industry are the fish and shrimp diseases


IntraFish

My Alerts

Indian shrimp production could fall by up to 30 percent this year Photo: IntraFish

Indian farmers 'completely clueless' as new shrimp disease spreads

The growing threat is leading to loss-making sales, and could bring down total volume by as much as 30 percent this year.

SeafoodSource

NEWS | SEAFOOD2030 | E-RESOURCES | PRODUCT SHOWCASE | DIRECTORY

Disease challenges biggest obstacle to India's shrimp success

By Chris Chase
October 25, 2019

SHARE

Continued challenges due to white spot, Enterocytozoon Hepatopenaei (EHP), White Feces Syndrome, and other diseases are the largest obstacles to increasing India's shrimp production, according to multiple industry experts in the region ...

15/04/19

New diseases threaten aquaculture

There are many factors contributing to the disease challenge including:

- increased globalization of seafood trade and markets
- intensification of fish & shrimp-farming practices
- introduction of new species and production areas for aquaculture
- large areas of monoculture production of (non-endemic) species
- expansion of the ornamental fish trade
- (unanticipated) interactions between cultured and wild populations of aquatic animals
- poor hygiene and lack of effective biosecurity measures
- slow awareness on emerging diseases
- climate change and environmental degradation
- irresponsible use of veterinary drugs

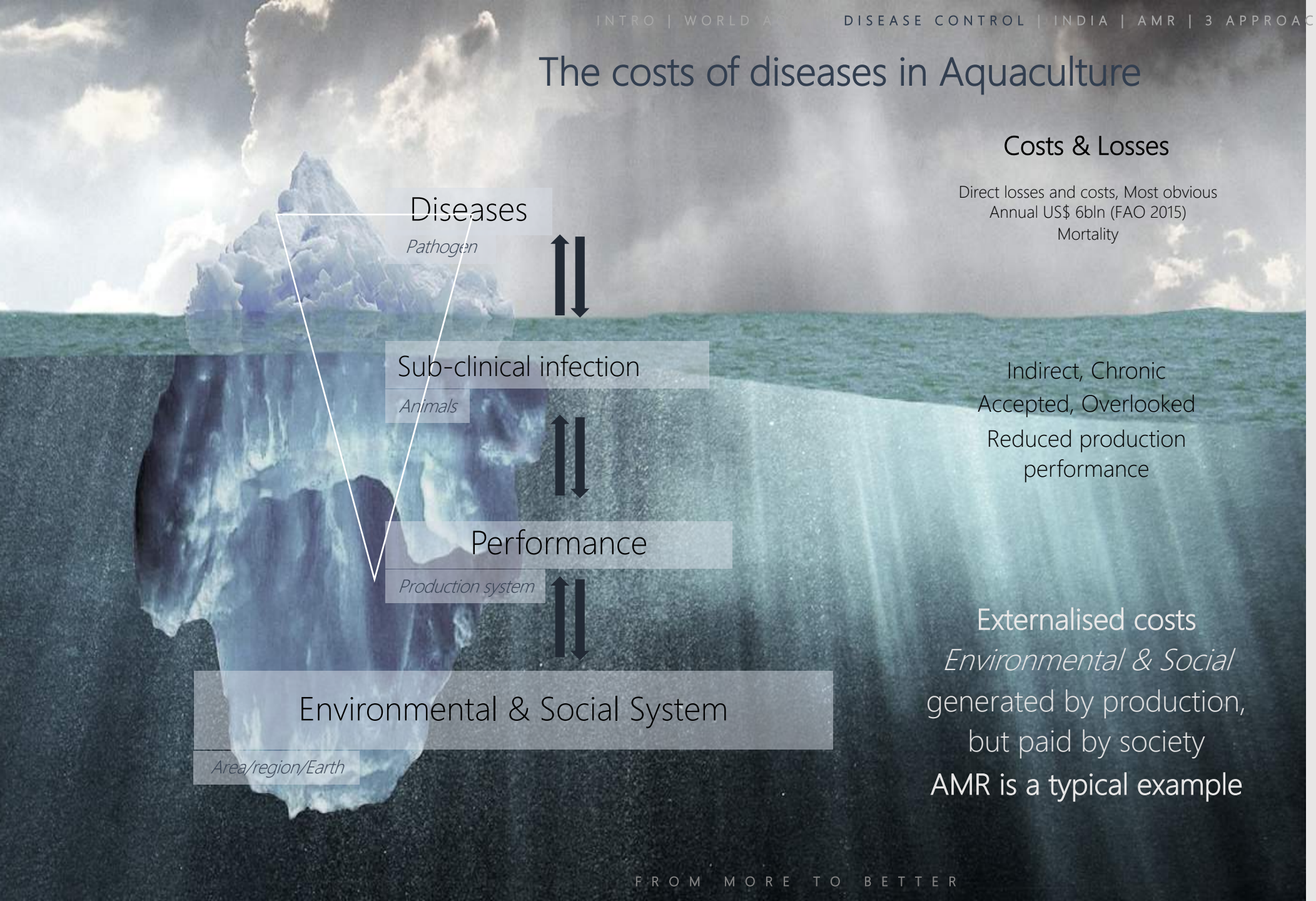
Disease Control in Aquaculture

The costs of diseases

Disease outbreaks are recognized as a major constraint to aquaculture production and trade and are affecting economic development of the sector in many countries of the world. This is especially the case for the shrimp culture sub-sector.

Some data are available on direct financial losses which indicate the significance of the problem, although social and other related impacts, such as trade, trust and employment issues, chemical and drug use, environmental degradation and AMR, have never been properly quantified. These additional and externalised costs are expected to be much bigger than the costs of disease outbreaks alone.

The costs of diseases in Aquaculture



Costs & Losses

Direct losses and costs, Most obvious
Annual US$ 6bln (FAO 2015)
Mortality

Indirect, Chronic
Accepted, Overlooked
Reduced production performance

Externalised costs
Environmental & Social
generated by production,
but paid by society
AMR is a typical example

We have the tendency to solve/fix the problem that is most obvious

Resulting in antimicrobial mis- and overuse in aquaculture

However, disease events represent only the tip of the iceberg

Additional problems are much bigger;
Environmental,
Climate,
Social
And Financial

Antimicrobial use in Aquaculture production

The availability and use of effective antimicrobials is essential for the health and welfare of terrestrial and aquatic animals, and their appropriate and prudent use has an important role in productive and sustainable agriculture and aquaculture (FAO, 2021).

The levels and patterns of antimicrobial use in aquaculture globally remain largely undocumented. This hampers the application of targeted interventions and policies promoting sound antimicrobial stewardship in this rapidly growing industry.

It is projected that global aquaculture consumption will increase 33% by 2030 (Schar *et al.*, 2020).

www.nature.com/scientificreports

scientific reports

OPEN

Global trends in antimicrobial use in aquaculture

Daniel Schar[1✉], Eili Y. Klein[2], Ramanan Laxminarayan[2,3], Marius Gilbert[1,4,6] & Thomas P. Van Boeckel[2,5,6]

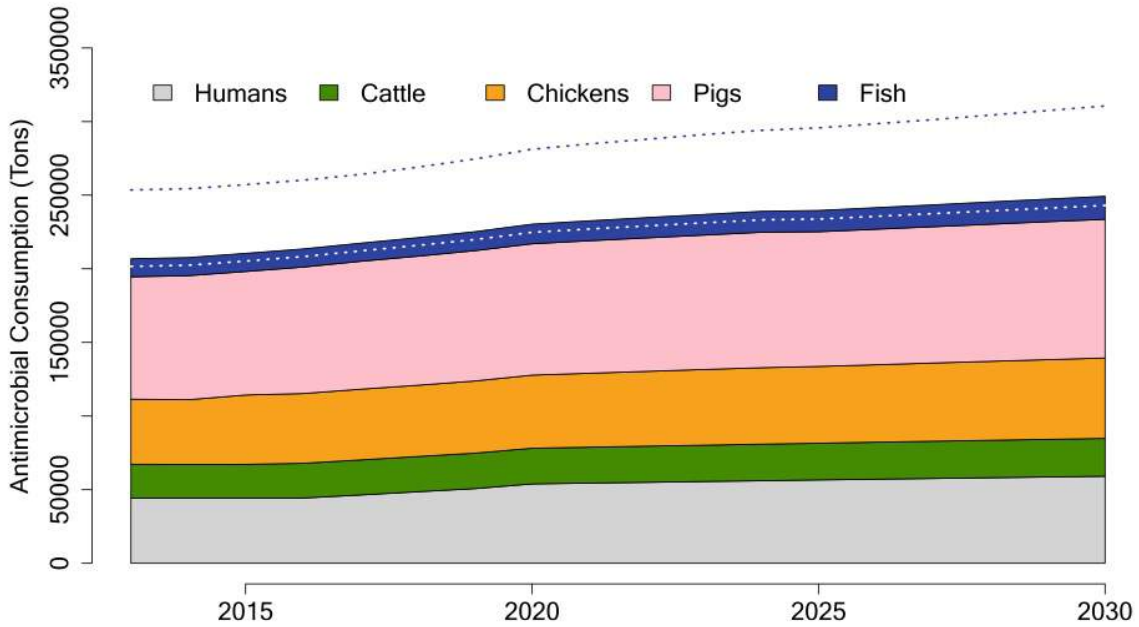


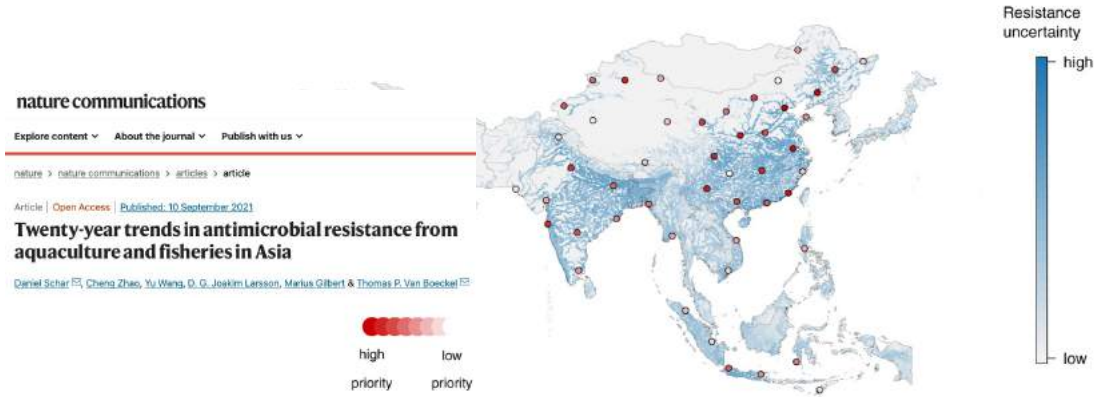
Figure 3. Global antimicrobial consumption, 2013–2030. Dotted lines represent the 95% uncertainty interval for fish.

www.nature.com/scientificreports/

Figure 1. Antimicrobial consumption in aquaculture in 2017 and 2030 (projected, Supplementary material).

Fig. 4: Future survey locations prioritized to reduce uncertainty in antimicrobial resistance in freshwater environments in Asia.

From: Twenty-year trends in antimicrobial resistance from aquaculture and fisheries in Asia



The background color gradient (blue) represents weighted uncertainty in multi-drug resistance (see "Methods" section). An initial set of 50 future surveys optimized to reduce uncertainty in multi-drug resistance is displayed (red).

Structural causes of diseases in Aquaculture production

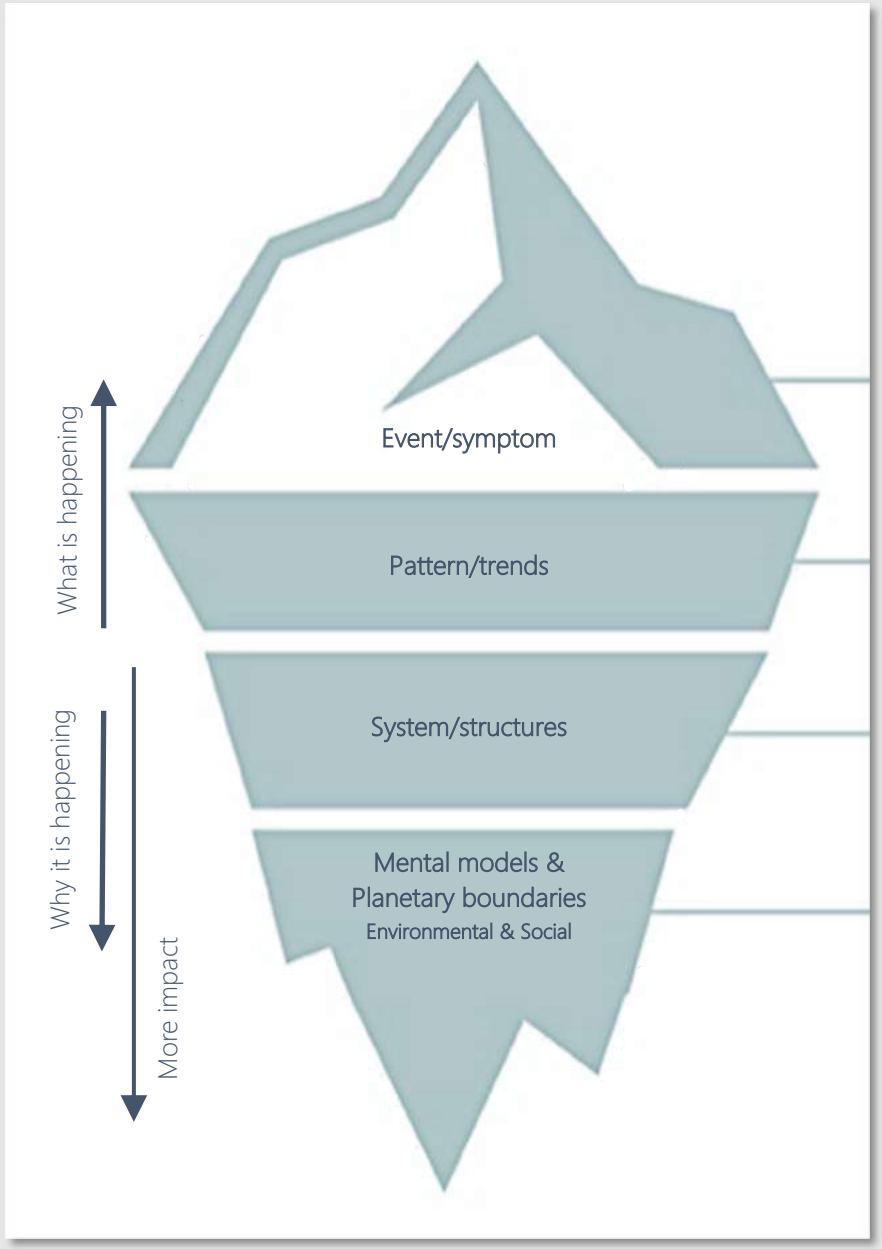
Diseases in aquaculture occur as a resultant of the complex interaction between the host, potential pathogens and the environment.

A lot of effort is put on solving disease problems in a one-dimensional way. However, in aquaculture production, and especially in the shrimp culture sub-sector, disease treatment is often not effective.

Intensification of monoculture production, environmental degradation, water quality deterioration, deforestation (incl. loss of mangroves), globalisation and climate change contribute to disease outbreaks.

More reasons why antimicrobials are not effective in aquaculture

- There are no or very limited veterinarian professionals who can subscribe specific treatments for prudent and responsible use
- There are no or very limited specific treatments available for most of the fish and shrimp diseases
- Co-occurrence of different types of diseases and limited availability of diagnostics hamper reliable diagnosis
- Sick animals lose appetite and application of medicated feed may be ineffective
- Individual treatment of animals is not possible in aquaculture
- Antibiotics can kill 'bad' bacteria, but also the 'good' bacteria and may leave the host weaker after treatment
- Antimicrobial compounds may kill pathogens, but will not cure; the body is doing that itself
- Frequent use of antimicrobials has led to the development of resistant microbes, leaving future on-farm treatments ineffective
- Most of the antimicrobials or other chemicals end up in the environment and contribute to pollution, stress and AMR-spread
- Use of antimicrobials is expensive and there is still a lot more to be gained from implementation of simple and inexpensive best management practices, such as increasing hygiene and biosecurity, reducing stress conditions and DO measurement



System Innovation to address AMR from Aquaculture

Fixing 1 problem rarely makes sense

It is much faster, easier and cheaper to address the root causes in a holistic approach

What happened? – obvious evidence
Tendency to React to solve/fix the problem
Disease outbreak – treat the disease

Notice trends to anticipate
What happened over time? – monitoring, surveillance
Disease problems increase over time/in certain areas – surveillance and epidemiology to anticipate and prevent

What systems, organisation, standards influence the pattern?
Where are the connections between the patterns?
Increased stress with increased density, monoculture production of non-endemic species

What beliefs, assumptions, values, traditions do people have to support the system?
We need to increase production and efficiency in order to feed the world and earn a living (current belief)

Addressing problems only on their event/symptom level (often through supplying sectors) works for superficial events, but is often not enough in case more systemic problems occur; the real causes are often hidden from plain sight, especially in aquaculture

Monitoring individual events allows to observe trends over time and allows more options to anticipate when noticing a pattern

When we see the underlying system structure, we can start to see where to change what is happening

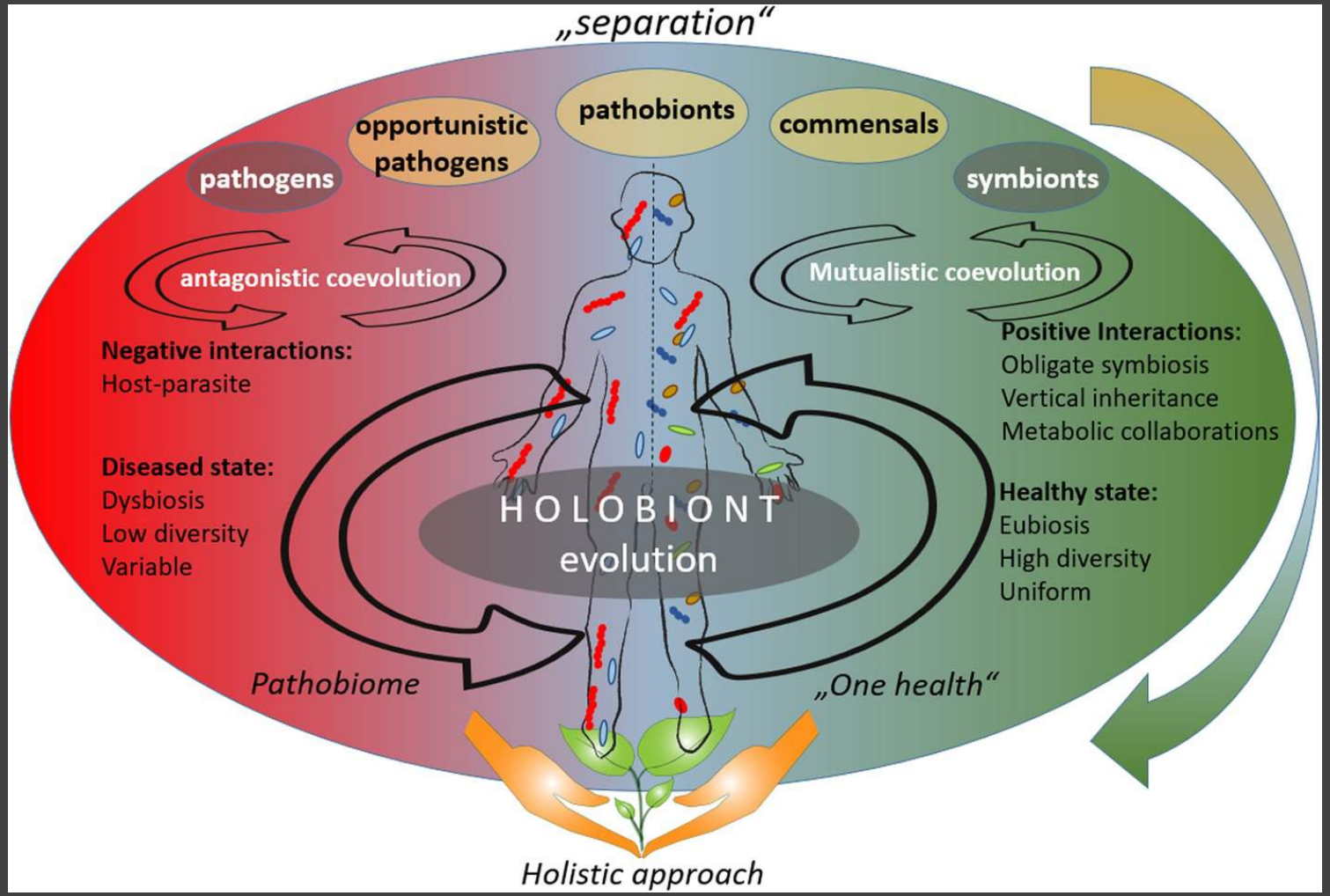
The system structures are based on mental models and includes the environmental and social contexts. This stage needs to be addressed to restructure the system which can lead to real transformation

FROM MORE TO BETTER

More reasons for stronger focus on resilient systems

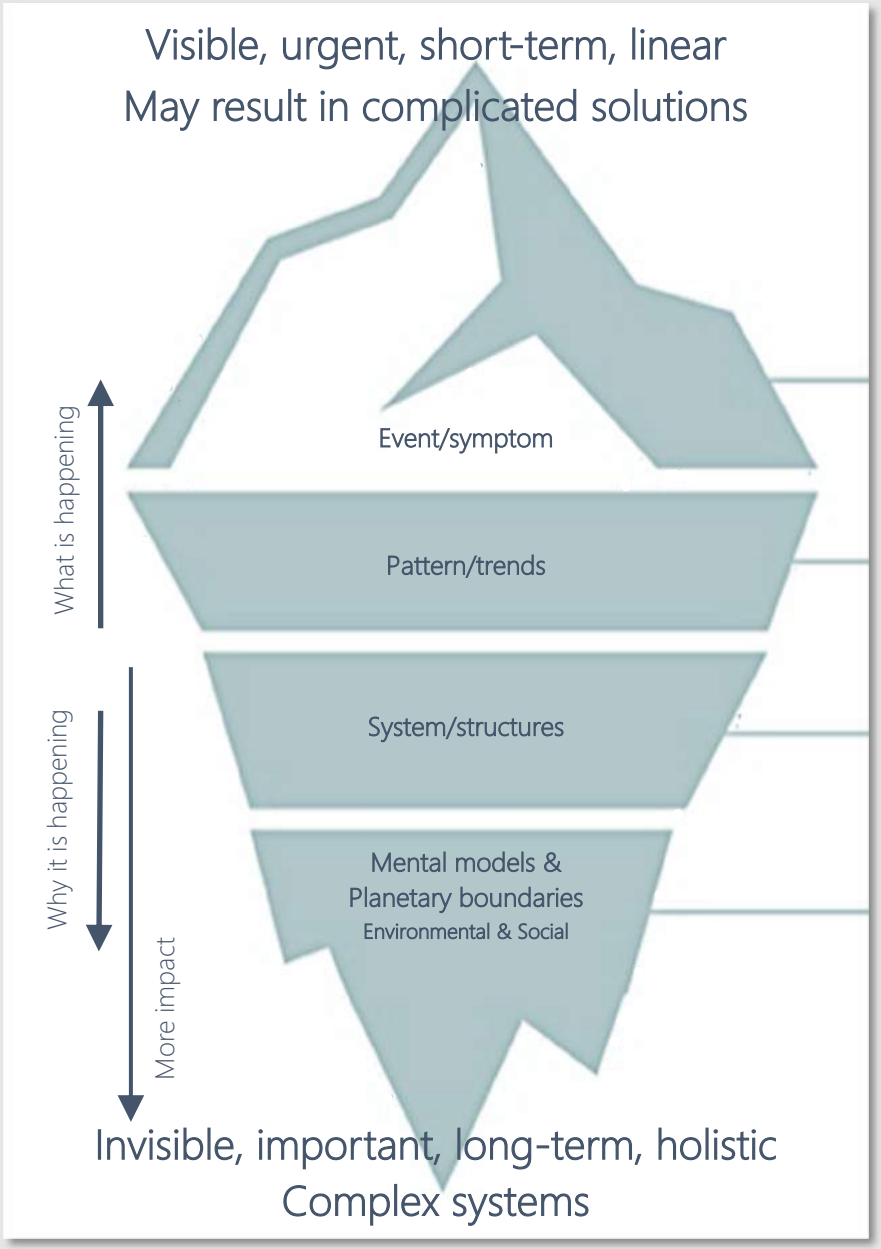
- With production increase and intensification, disease problems will increase and new diseases will certainly emerge
- Diseases occur as a combination of suboptimum factors within the host, microbes and the environment
- Aquaculture situation is often favourable for opportunistic pathogens; microbes causing disease in animals with a compromised immune system or in a suboptimum environment; diseases occur when fish are weakened by stress
- In aquaculture production, and especially in the shrimp culture sub-sector, there are plenty of examples of good farming practices and production performance where antimicrobials are not needed and not used

More reasons for stronger focus on resilient systems



A shift in the understanding of the microbial-host coevolution from the "separation" theories to the holistic approach. The hosts and their associated microbiota are assumed to have coevolved with each other, whereby different approaches are considered to describe the coevolution theory. According to the "separation" approach (upper part of the figure), the microorganisms can be divided into pathogens, neutral, and symbionts, depending on their interaction with their host. The coevolution between host and its associated microbiota may be accordingly described as antagonistic (based on negative interactions) or mutualistic (based on positive interactions). The recent emerge in publications about opportunistic pathogens and pathobionts gave a shift towards holistic approach in the coevolutions theory (lower part of the figure). The holistic approach sees the host and its associated microbiota as one unit (so-called holobiont), that coevolves as one entity. According to the holistic approach, holobiont's disease state is linked to dysbiosis, low diversity of the associated microbiota, and their variability: a so-called "pathobiome" state. The healthy state, on the other hand, is accompanied with eubiosis, high diversity, and uniformity of the respective microbiota. The dynamic flow of microorganisms from one host to another and to the environment, described by the One Health concept, underpins the holistic approach in the coevolution

Berg, G., Rybakova, D., Fischer, D. et al. Microbiome definition re-visited: old concepts and new challenges. Microbiome 8, 103 (2020). https://doi.org/10.1186/s40168-020-00875-0



One step further down towards the foundation

Nature-positive, carbon-negative and inclusive aquaculture production systems can contribute to a healthy food system, better human health system, reduced pollution and improved water quality in an area, at the same time reducing biodiversity loss, climate change and social inequalities.

These more resilient culture systems will improve culture conditions, reduce disease problems and don't need chemical treatment. It is much easier and cheaper than 'fixing problems' afterwards.

The big gain lies in the combination of the different factors and their symbiotic relationships.

FROM MORE TO BETTER

Health Management in Aquaculture

From more to better - -

Doing 'less bad'

Diseases

Pathogen

Sub-clinical infection

Animals

Performance

Production system

Environmental & Social System

Area/region/Earth

Doing 'good'

- Doing better will generate more -

Nature, climate, biodiversity, equality

Resilient systems are the very foundation and essential for the future of life on earth

When we focus on creating resilient production systems, the risk of disease outbreaks will significantly decrease

Focus on the foundation is easier and much cheaper than fixing problems afterwards

And it will have a lot of other additional benefits

The situation in India

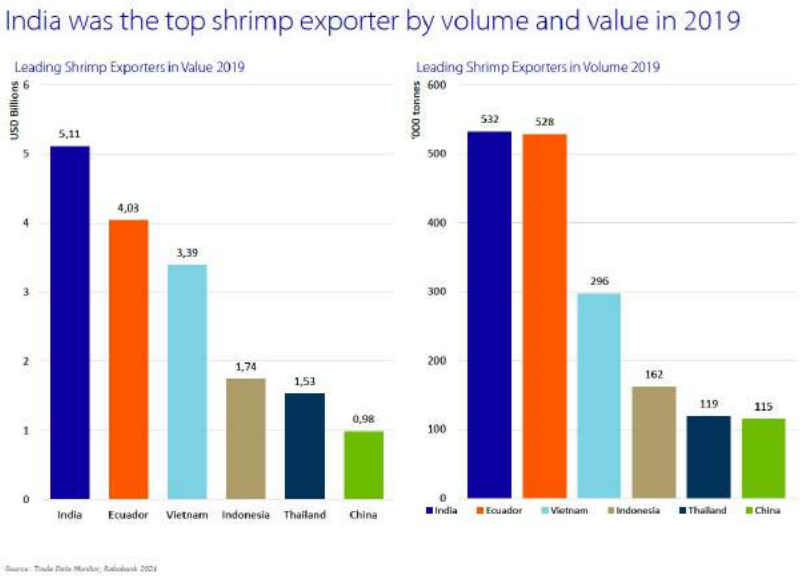
India is one of the world's biggest aquaculture producers with shrimp as single biggest export commodity. The sector is still rapidly growing and plans are to double export in the coming years. Production increase and intensification will increase the risk of disease outbreaks and are potentially driving antimicrobial use and also antimicrobial resistance.

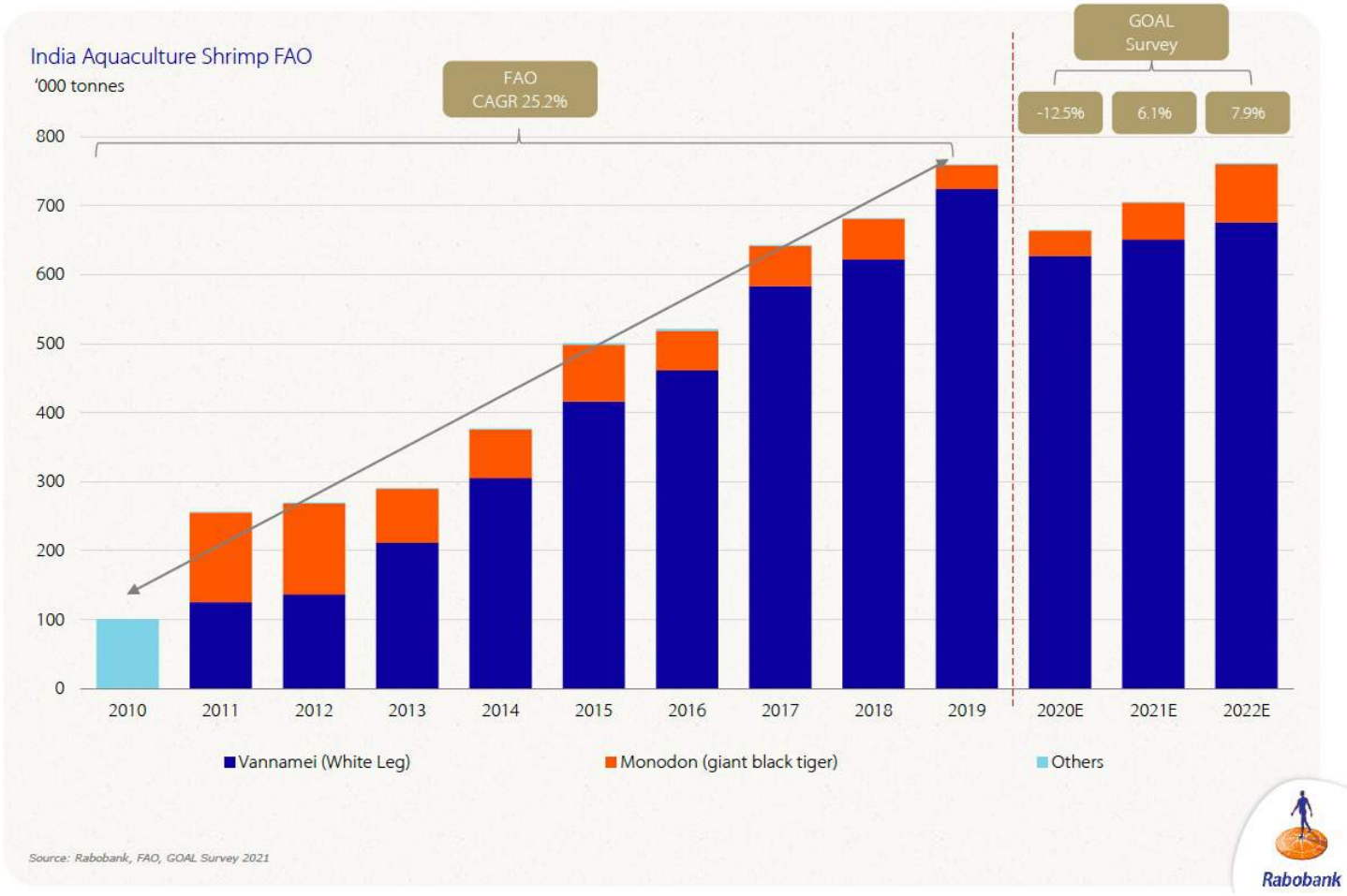
AMR in Indian Aquaculture

Compared with antimicrobial use in terrestrial animal production, application of antimicrobials in aquaculture provides a potentially wider environmental exposure pathway for drug distribution through water with important ecosystem health implications. Therefore, urgent steps are necessary to halt its progress and spread.

Solidaridad India conducted a field study through interviews with key-stakeholders and a survey among shrimp farmers. Others studies were conducted by major farmers and exporters in the sector. The results show possible entry points and suggestions for AMR control.

Shrimp Production Quantity & Export





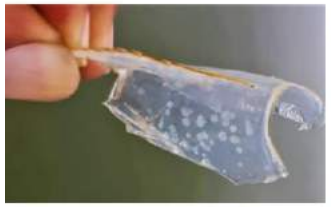
Results
Local Study

Dr. Manoj M. Sharma
Managing Director
Mayank Aquaculture Private Limited

State wise shrimp production (MT) in India - 2021

Andhra Pradesh	480.000
West Bengal	62.000
Odisha	57.000
Gujarat	23.400
Tamil Nadu	21.000
Rest of India	7.000
Total	**650.400**

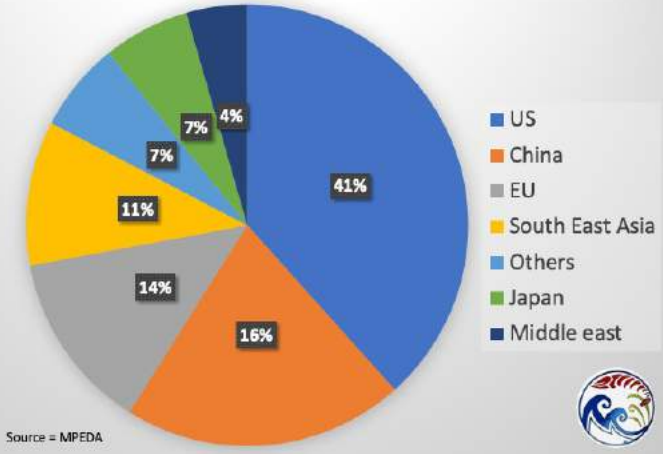
Diseases still the major culture issue




- Less seed (PL) survival.
- Slow growth- High FCR.
- EHP, Vibrio and Atropy of Hepatopancreas
- IMNV (Recent)
- Running mortality.
- White gut/ White feces.

Still the major damage caused by WSSV

Market wise Seafood Export by value India



Farmer's perspective towards use of "Antibiotics"

- Main goal to make the shrimps disease free
- No prudent way to use antibiotics to mitigate diseases
- Fear among the farmers due to increase in the disease incidence
- Fear among the farmers as the diseased material is being rejected in the export market
- Fear of losing money and livelihood

Shrimp Production India

Shrimp contributed >50% in quantity and 75% in financial export earnings from seafood in 2020/2021

EU is the 3rd largest destination of Indian seafood with 14% in financial value with shrimp as the major product

Boost in production after introduction of *P. vannamei*

World's 2nd largest producer of *P. vannamei* (13%)

Plans of doubling export products

In list of Top MRL Violations

Reduction in residues during the last years

Production losses India

Journal of FisheriesSciences.com Patil et al., 15(S1-002): 013-015 (2021)

Journal abbreviation: J FisheriesSciences.com

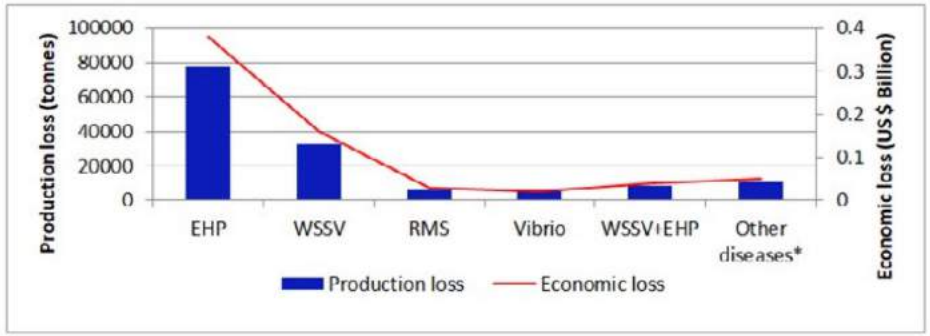


Figure 2: Production and economic loss due to shrimp diseases in India.

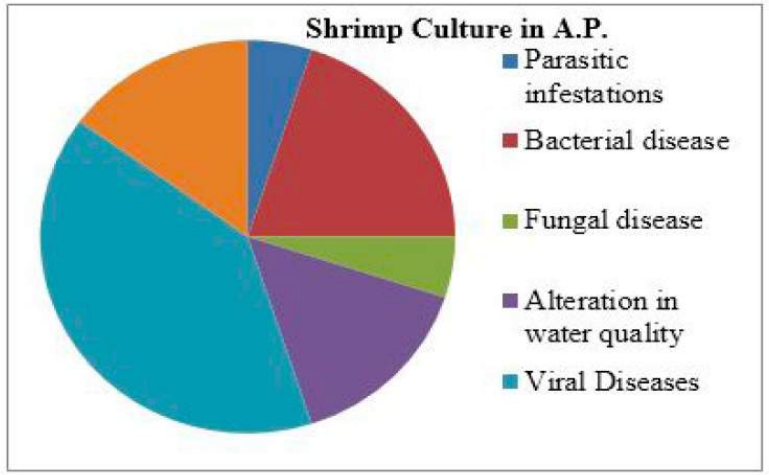


Figure 5: Showing prevalence of various disease problems in Shrimp aquaculture in Andhra Pradesh (A.P).

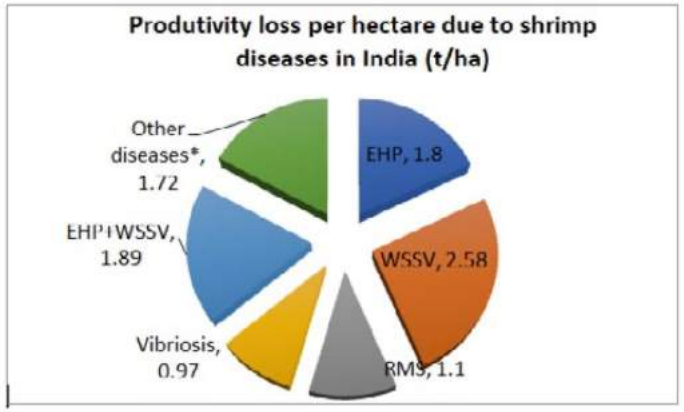
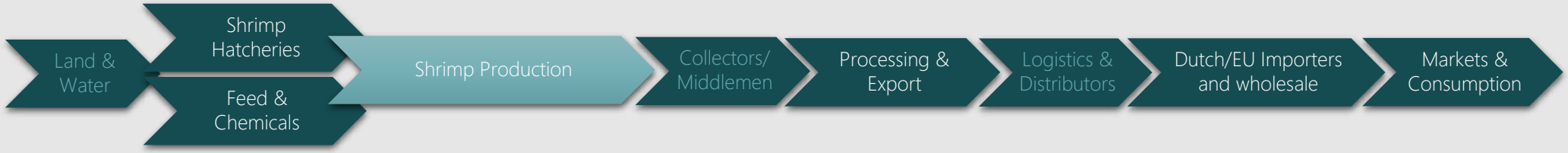


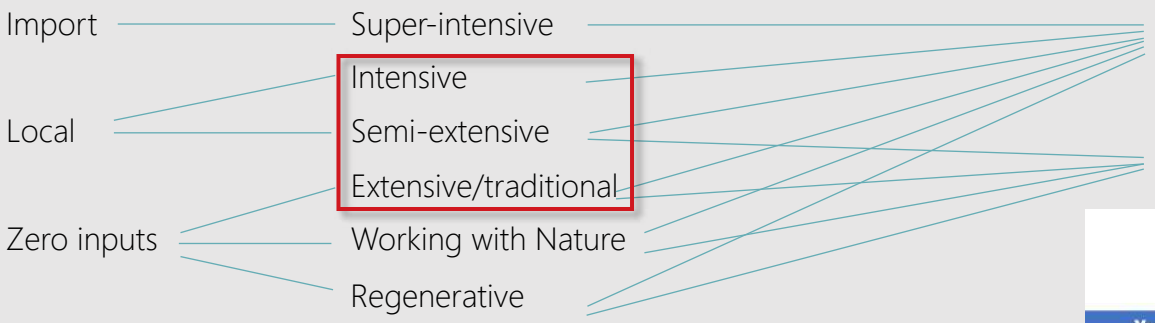
Figure 1: Productivity loss due to shrimp diseases in India.

Wide diversity in aquaculture (shrimp) production systems



Production systems currently mostly used in India

Aquaculture systems vary in their levels of parameter control



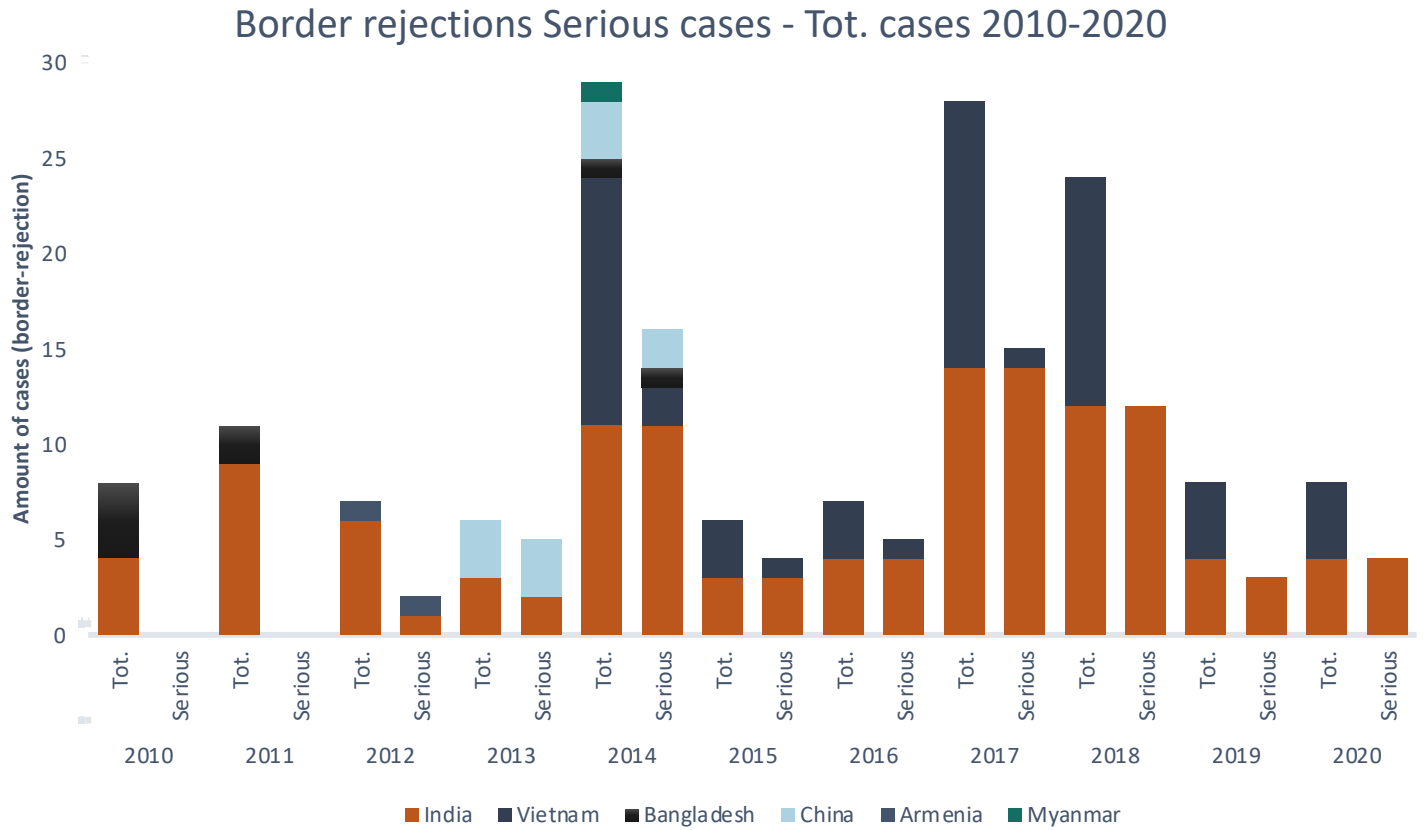
Reducing success rate with increasing production

Production trends v/s Success

Year	Total seed Production (in billion)	Total shrimp production (in tons)	% of success	Remarks
2010	2.2	47 000	85	
2011	4.5	83 000	74	
2012	9.0	145 000	64	
2013	18	247 000	55	
2014	23	317 000	55	
2015	32	353 000	44	
2016	38	380 000	45	
2017	60	650 000	48	
2018	66	740 000	53	
2019	70	805 000	55	
2020	72	645000	48	

Note: Calculated shrimp count @ 40 to 50 pcs/Kg

European Border rejection cases



Trends in cases of shrimp imports rejected by the European Union of exporting countries from 2010-2020. Data obtained with the RASFF-Portal for the Food and Feed Safety Alerts. Search criteria that were used: notified from 01/01/2010 | notified till 19/01/2021 | Notification type border rejection | Product category crustaceans and products thereof | Hazard category residues of veterinary medicinal products.

Results local studies India

Results Local Study

Survey and interviews carried out among key players in the sector in Q2, 2021

Possible entry points of antimicrobials and risks of AMR in Indian Aquaculture sector

- Mixing of fresh water by getting contacted with the previously used untreated water
- Possible pollution through antibiotics, resistant bacteria and human/animal pathogens
- Use of human and animal waste containing pathogens, to fertilize the pond to encourage the growth of algae on which the shrimp feed
- Unregulated use of antibiotics, added directly to the pond-water and/or to the animals/humans living there
- Pond sediment/sludge containing antibiotics and resistant bacteria/pathogens is used as fertilizer for chicken feed and crops
- Effect of temperature increase and global warming
- Use of already banned items i.e. Nitrofurans, Chlorofenical and Oxy-tetra cycle; detected based on rejections and public reports
- Antibiotics are found at hatchery level or at the farm level or both
- Hatchery owner and staffs are not really care and use to increase production and to deal with vibrio problems, Farmers are also not care on that issue
- Surface contact with worker as it is labour oriented activities
- During harvesting time farmers are not aware about it
- Strengthening implementing NRCP (National Residue Control Programme) to control use of antibiotics in Aquaculture

Results
Local Study

Survey and interviews carried out under key players in the sector in Q2, 2021

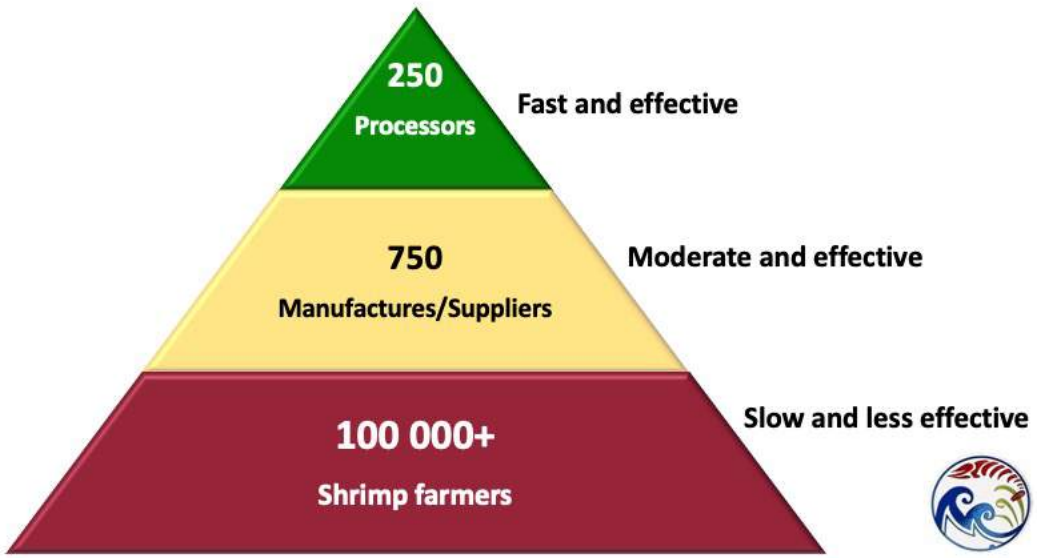
Suggestions for controlling of AMR

- Strengthening of surveillance system for use of antibiotics in healthcare
- Emphasis needed to the food and environment sector
- Strengthening the laboratory capacity
- Bridge among the regulatory and enforcement agencies
- Better regulation of feed and pro-biotic manufacture and sells
- Reduce the infection loss due to AMR pathogens by providing assured quality medicines
- Creating awareness and understanding among general public
- Effective infection, prevention and control programme
- Development of alternate to antibiotics protocols
- Strengthening the certification procedures and BMP

Results
Local Study

Dr. Manoj M. Sharma
Managing Director
Mayank Aquaculture Private Limited

Suggestive measures,
Q3, 2021



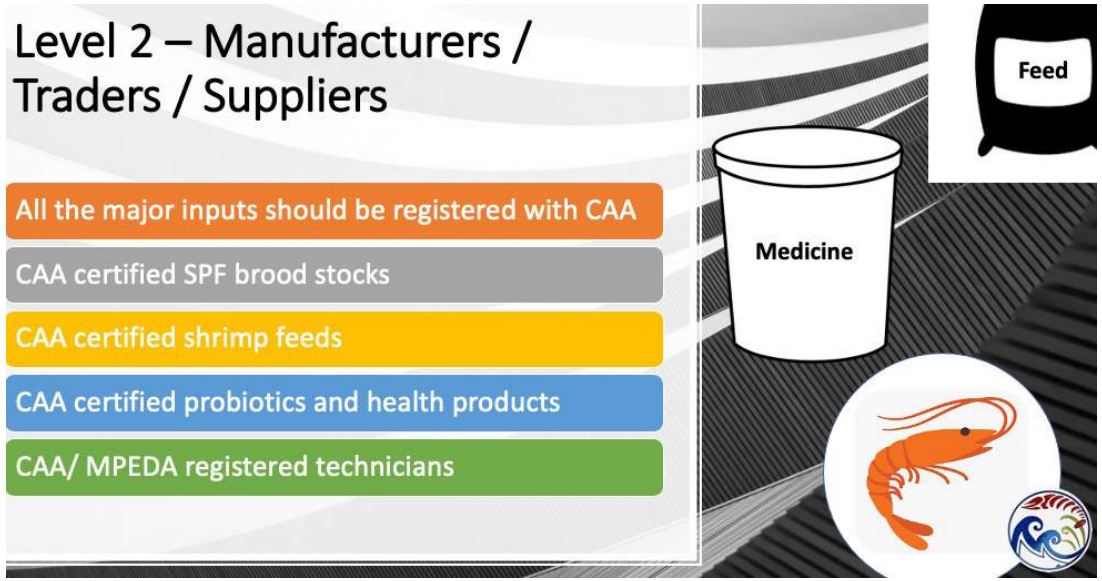
Level 1 - Processors

- Total numbers of Exporters < 250 – Easy to implement
- PHT - compulsory by processors/ Exporters
- Method of testing for antibiotics – LCMS
- Test- Direct antibiotics, not its metabolite
- Promotion of private labs with accreditations
- MPEDA/ NFDB assistance to establish LCMS lab

Results
Local Study

Dr. Manoj M. Sharma
Managing Director
Mayank Aquaculture Private Limited

Suggested measures,
Q3, 2021



Results
Local Study

Dr. Manoj M. Sharma
Managing Director
Mayank Aquaculture Private Limited

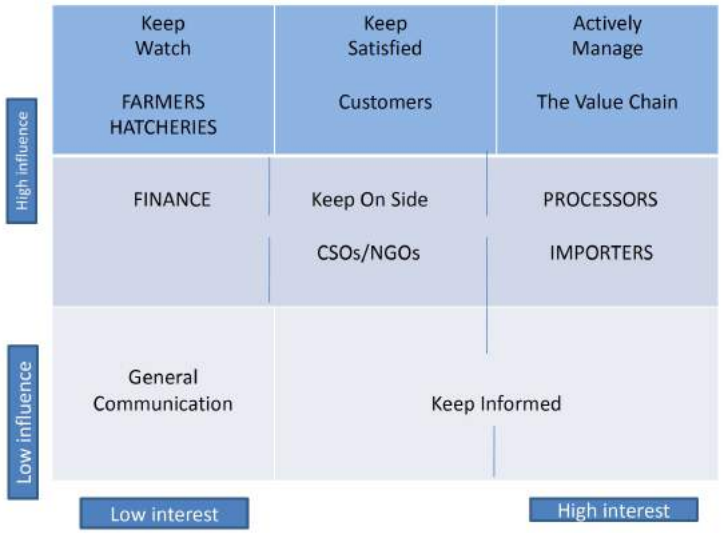
Suggestive measures, Q3, 2021

Conclusion

- In the current scenario its advisable to take the measures from the shrimp processor/exporter level as its very fast and effective.
- Corrections in **level two** will bring long term sustainability as everything depends upon quality inputs.
- Once the top 2 levels implemented properly, **the 3rd level** will get automatically corrected as it is dependent on **level 1 and 2**.
- Shrimp/livestock is subjected to diseases and there should be a prudent way of using medicines. Competent authorities should suggest some protocol.
- Farmer training and awareness programs should be focused on Food safety modules as international market drive is on **"SAFE SHRIMP"**.

Results Local Study

Processors perspective



Indo-Dutch Sustainable Shrimp

- Finance by Rabobank / Rabobank Foundation
- Seed by Kona Bay
- Feed + Inputs by Skretting
- EU Processors
- Importers (Klaas Pull)
- Solidaridad / IDH for Monitoring

One Health principle

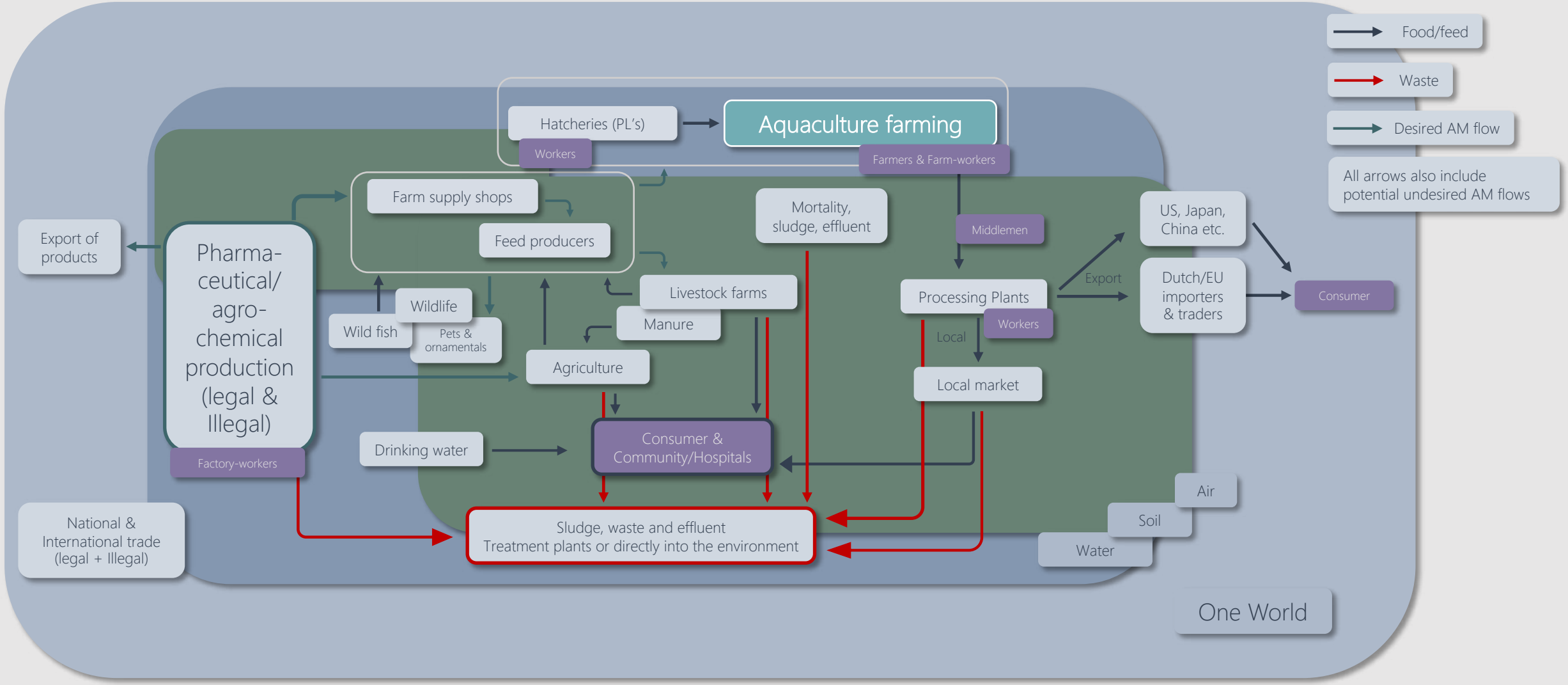
Besides AMR in human and animal health, the natural environment requires attention as well, as animal health, human health, and environmental health are intrinsically related

The environment, including wildlife and water bodies, is also an important reservoir of drug-resistant microbes and may be prime localities for development and spread, especially in places with inadequate hygiene and water supply

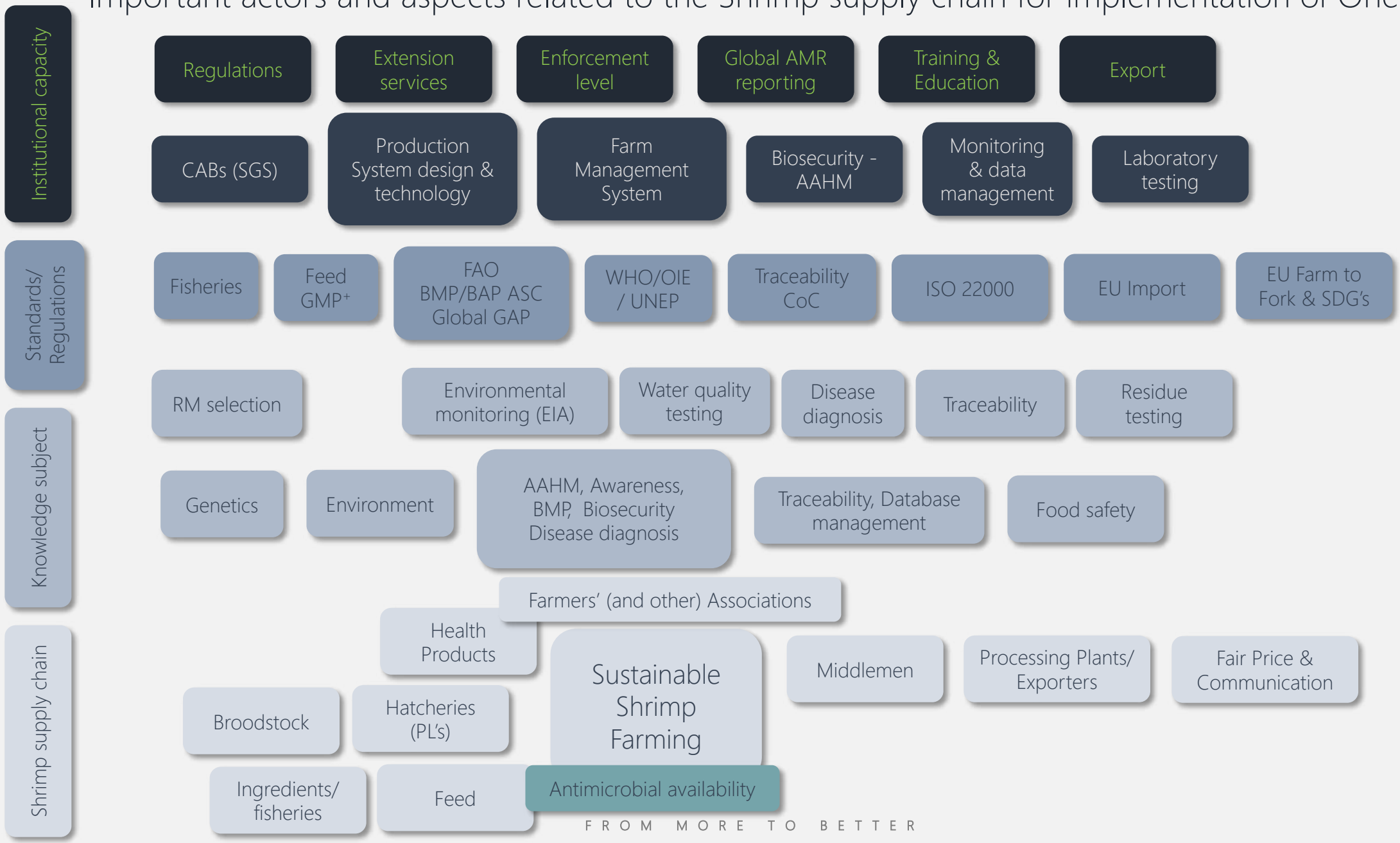
The spread and impact are especially complex for the aquaculture sector, therefore requires multisector collaboration

The cycle of antibiotics and potential flow of (M)AMR in relation to the shrimp sector with export to Europe

AMR is multi-faceted with deep linkage to human, animal and environmental health



Important actors and aspects related to the Shrimp supply chain for implementation of One Health



Shared responsibilities

The Netherlands/EU are importing seafood from India and AMR must be a shared responsibility.

Globally we are only as protected as our most vulnerable members, because resistant microbes easily cross borders. Therefore, AMR should be addressed broader than at the level of export products alone.

India is a major antibiotic consumer worldwide and is one of the countries mostly affected by AMR.

In addition, India is one of the major manufacturing countries of antibiotics for the world market, especially low-cost products are exported to low-income countries. And, in like manner, India can take its responsibility in this part as well, as AMR problems are rising at an alarming rate in these areas.

EU nature restoration targets

© ollo / Getty Images

The European Commission will put forward a proposal for legally binding EU nature restoration targets in 2021. Restoring EU's ecosystems will help to increase biodiversity, mitigate and adapt to climate change, and prevent and reduce the impacts of natural disasters.

WWF

European Commission

Beyond Forests: Reducing the EU's footprint on all natural ecosystems

Law

Protecting biodiversity: nature restoration targets under EU biodiversity strategy

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Towards sustainable and circular farming in the Netherlands: Lessons from the socio-economic perspective.

November 2020

Hans C.J. Vrolijk · Joan Reijs · Marijke Dijkshoorn

Agricultural intensification a house of cards: challenging the current agricultural system

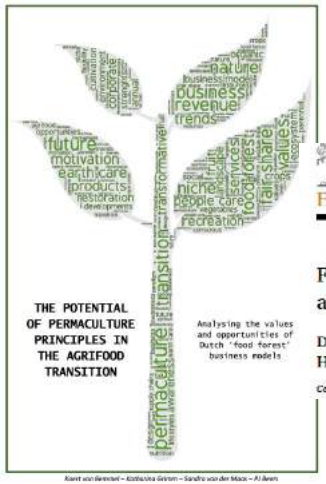
Utrecht University

India-Netherlands Joint Statement during visit Minister of Netherlands to India (May 24, 2018)

News item | 11-07-2018 | 06:19

India-Netherlands Joint Stat
visit of Prime Minister of Net
India (May 24, 2018)

1. At the invitation of Prime Min
Narendra Modi, Prime Ministe
theNetherlands Mr. Mark Rutt
Official Visit to India on 24-25
The two leaders held wide ran
constructive discussions on a
regional and international issu
underlined the growing conve
between the two countries an
deepen and strengthen the long-standing



European Commission

Realisatieplan Visie LNV
Op weg met nieuw perspectief

Home › Strategy › Priorities 2019-2024 › A European Green Deal

A European Green Deal

Striving to be the first climate-neutral continent

AgroEcological Transitions

Changes and Breakthroughs in the Making

ELSEVIER

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Five mechanisms blocking the transition towards 'nature-inclusive' agriculture: A systemic analysis of Dutch dairy farming

D.A. Vermunt [1], N. Wojtynia [1,*], M.P. Hekkert, J. Van Dijk, R. Verburg, P.A. Verweij, M. Wassen, H. Runhaar

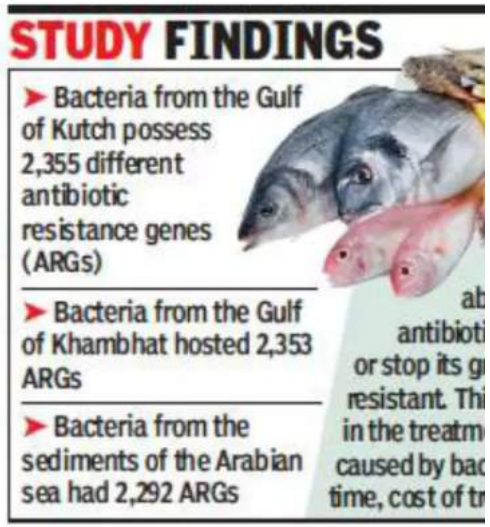
Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands

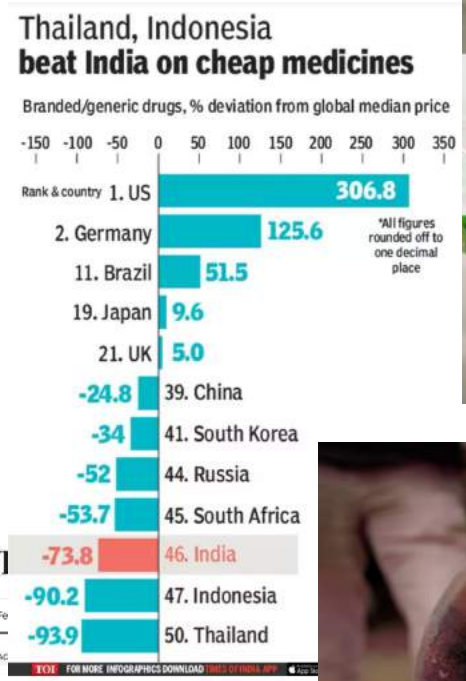
WAGENINGEN

The Netherlands is in the midst of transition towards sustainable agriculture production systems

This experience can be used to contribute to more sustainable practices in aqua-farming in India

https://www.footprintnetwork.org/netherlands/





The Journal of Antibiotics

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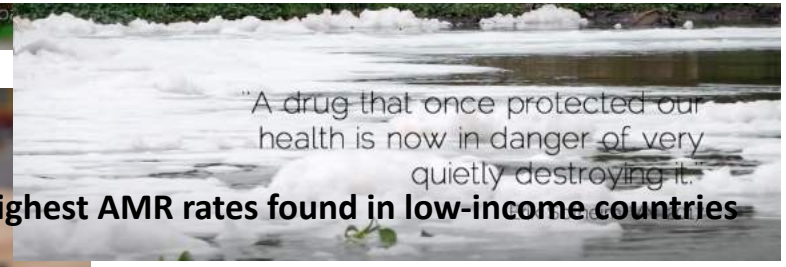
Review Article | Open Access | Published: 19 March 2020

Industry incentives and antibiotic resistance: an introduction to the antibiotic susceptibility bonus



The highest AMR rates found in low-income countries

THE TIMES OF IN

India | Ram Temple In Ayodhya | LAC Face-Off | #MaskIndia | Coronavirus Outbreak | Opinions And Fe

TOP SEARCHES | OMICRON VARIANT IN INDIA | RAHUL GANDHI | OMICRON CASES IN INDIA | LEGAL MARRIAG

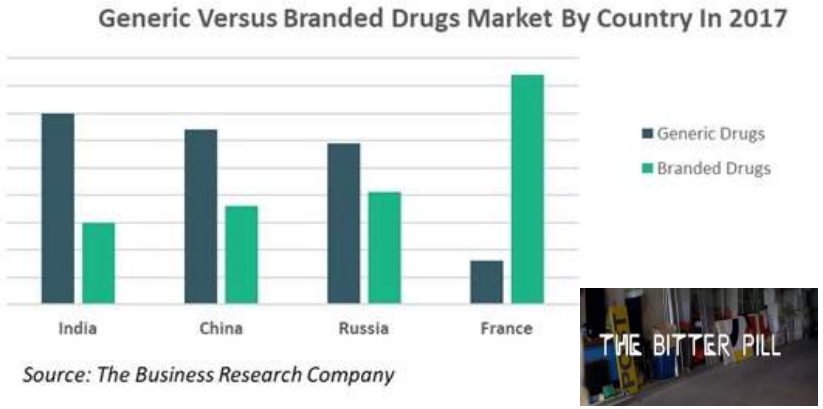
NEWS / INDIA NEWS / Indian Drug Prices Among The Cheapest In The World

THIS STORY IS FROM NOVEMBER 23, 2019

Indian drug prices among the cheapest in the world

TNN / Updated: Nov 23, 2019, 15:02 IST

The global antibiotics market is dominated by generic drugs sold at low prices



India is among the major exporters of cheap antimicrobials to low-income countries

Strengthening control of pharmaceutical companies for their pollution and trade is urgently needed for a major impact locally and worldwide

PART II

Roadmap design

AMR is complex

Effective national prevention measures are needed, but action at global level is essential for effective control of AMR. Furthermore, AMR is intertwined with other global problems and affects a broad range of interconnected sectors. Therefore, requires a holistic and systemic approach. We emphasise the urgent need for coordinated national and international interventions to limit antimicrobial production, use, misuse, abuse and waste at all levels.

ARTICLE NATURE COMMUNICATIONS | https://doi.org/10.1038/s41467-020-15735-

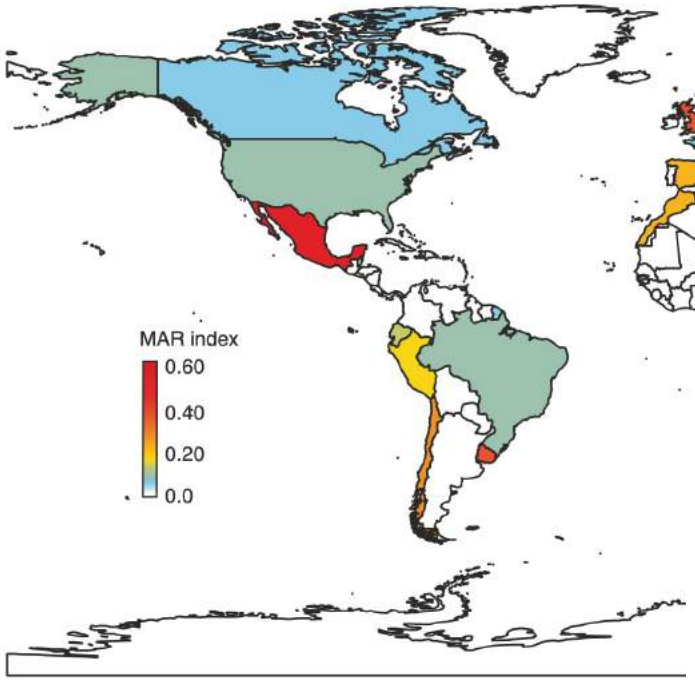


Fig. 2 Global multi-antibiotic resistance (MAR) index calculated from aqu due to data deficiency.

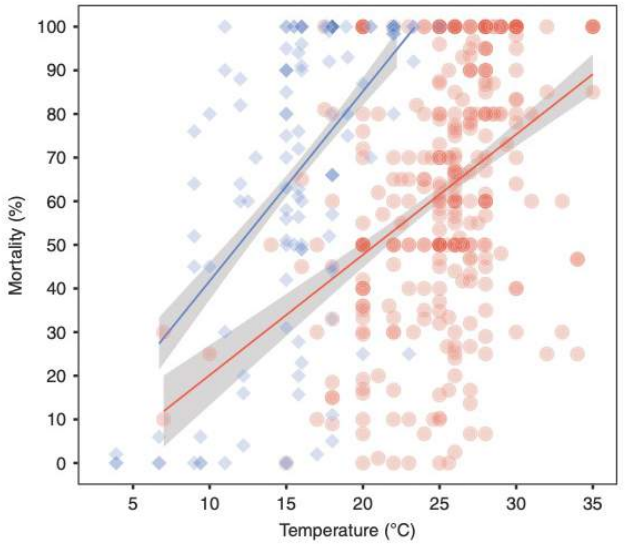


Fig. 1 Predicted changes in mortality (%) of reared aquatic animals infected by bacterial diseases in response to temperature (°C). Bacterial pathogens: *Aeromonas spp., Edwardsiella spp., F. columnare, Lactococcus spp., Streptococcus spp., Vibrio spp.*, and *Yersinia spp.* Red indicates tropical and subtropical host species ($n = 329$), blue indicates temperate host species ($n = 129$). Dots represent the raw data and the lines the linear mixed model predictions with SE.

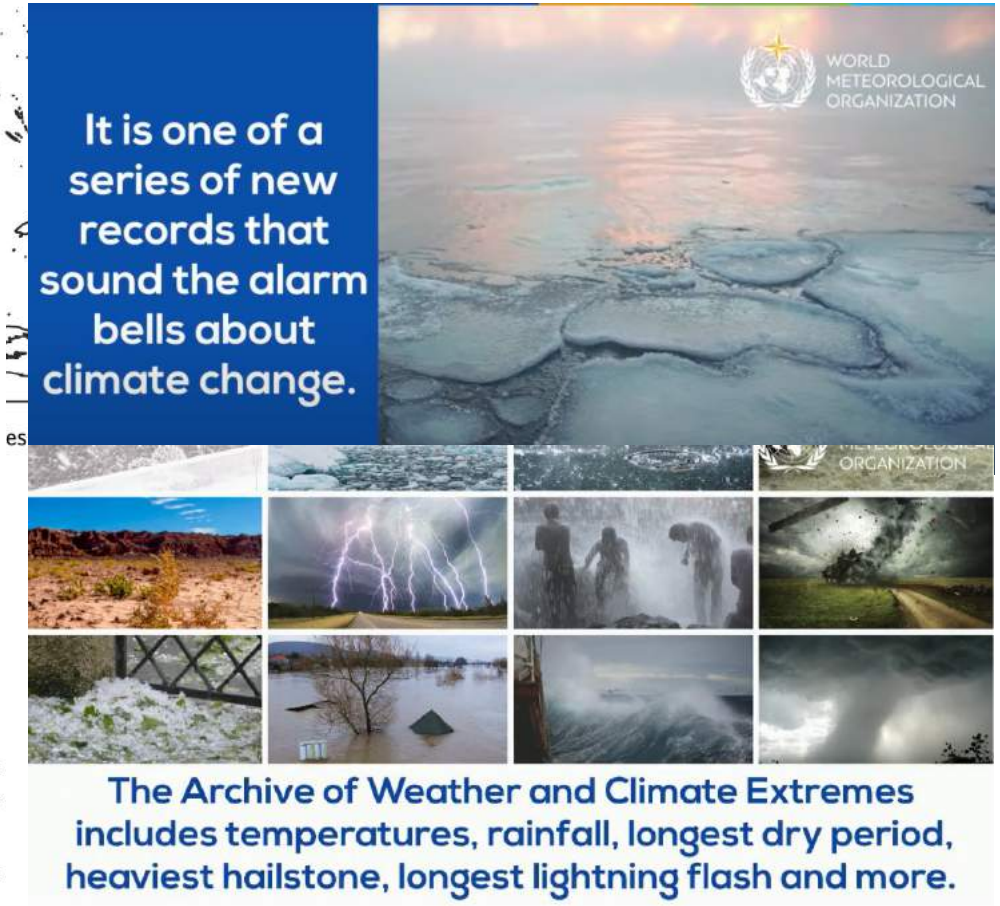
ARTICLE

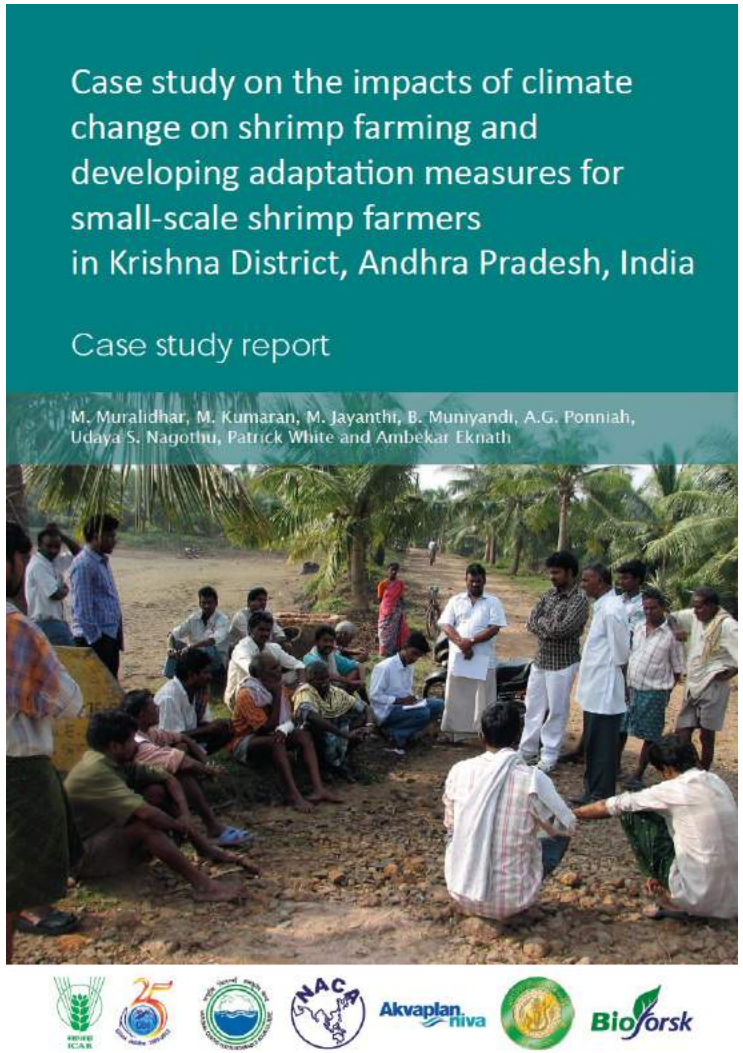
https://doi.org/10.1038/s41467-020-15735-6 OPEN

Check for updates

Aquaculture at the crossroads of global warming and antimicrobial resistance

Miriam Reverter[1,2✉], Samira Sarter[1,3], Domenico Caruso[1], Jean-Christophe Avarre[1], Marine Combe[1], Elodie Pepey[1,3], Laurent Pouyaud[1], Sarahi Vega-Heredía[1], Hugues de Verdal[1,3] & Rodolphe E. Gozlan[1✉]





AMR is related to other global challenges

India is heavily affected

TIPPING ELEMENTS

Literature review

The costs of climate change in India

A review of the climate-related risks facing India, and their economic and social costs

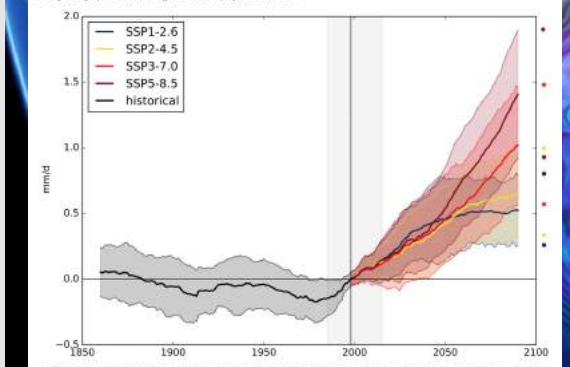
Angela Picciariello, Sarah Colenbrander, Amir Bazaz and Rathin Roy
June 2021

INDIAN SUMMER MONSOON

The Indian summer monsoon rainfall between June and September critically affects India's agriculture and economy. It is the primary delivery mechanism for fresh water in the Indian subcontinent. Global warming tends to strengthen the monsoon since warmer air can carry more water. Air pollution and land-use that increases the reflection of sunlight tend to weaken it. The Indian summer monsoon could become more and more unpredictable and in the worst case start to chaotically change between an active and a weak phase within a few years.

CAPTION: Indian summer monsoon (ISM)
CREDIT: Rain Accumulation | Globaia & NOAA National Climatic Data Center

These are fascinating results. Under most likely scenarios for future warming the monsoon will strength, with more rainfall on average. In graphical form the figure below displays the outcomes:



Multi-model mean of Indian summer monsoon rainfall (mm d−1) for the Indian summer monsoon for 1860–2090 relative to the mean (horizontal black line) in 1985–2015 (grey background) for the four scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5). The 20-year smoothed time series of one ensemble member per model was used to calculate the multi-model mean. Shading in the time series represents the range of mean plus/minus 1 standard deviation marked with circles on the right side of the figure. Image and caption (lightly edited) from Katzenberger et al. (2021).

Crossing these points threatens to irreversibly disrupt the natural systems that have kept Earth's climate relatively stable for thousands of years.

ENVIRONMENT

Climate change: Indian monsoon among nine tipping points

Saina Nair — February 12, 2020

Flood and Drought Due to the Indian Summer Monsoon. In India, GDP is additionally affected by variability of the summer monsoon, which determines the occurrence of drought or flood according to the ISM tipping module (48).

Figure 1 Projected physical and economic impacts of climate change in India

Climate change: physical impacts

Rainfall patterns

An extra two heatwaves (12–18 days at high temperatures) each year by 2064.[i]

Higher temperatures

Water flow in the Ganges and Brahmaputra to fall by 17.6% and 19.6% respectively by mid-century (compared to end of previous millennium).[ii]

Sea-level rise

Sea levels to rise by 20–30 cm by end-century (compared to current levels).[iii]

Storms and cyclones

Cyclones in the Bay of Bengal are projected to nearly double by 2070–2100, compared to 1961–1990.[iv]

Climate change: economic impacts

GDP

GDP in 2100 to be reduced by:

- 10% at 3°C of global warming due to declining agricultural productivity, sea-level rise and increased health expenditure.[v]
- 2.6% at <2°C global warming and up to 13.4% at over 4°C of global warming due to declining labour productivity from temperature and precipitation changes.[vi]
- 90% at 3°C of global warming, based on the historical relationship between temperature and GDP.[vii]

ANTIMICROBIAL RESISTANCE AND THE CLIMATE CRISIS

Information note of the Global Leaders Group on Antimicrobial Resistance. October 2021.

GLOBAL LEADERS GROUP ON ANTIMICROBIAL RESISTANCE

KEY MESSAGES

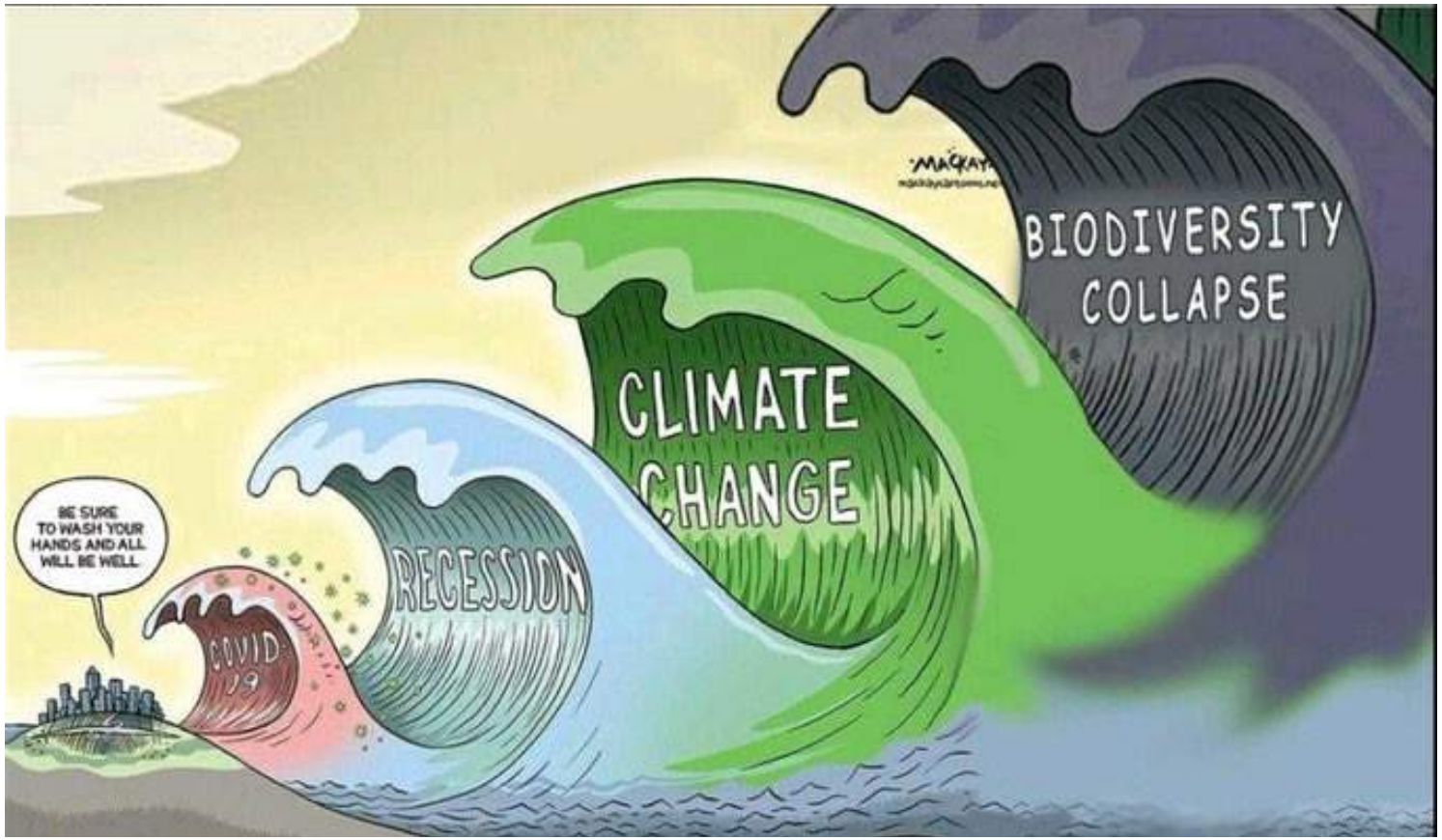
1. The climate crisis and antimicrobial resistance - the ability of microbes to resist the drugs designed to inhibit or kill them - are two of the greatest and most complex threats currently facing the world. Both have been exacerbated by, and can be mitigated with, human action.
2. The climate crisis is impacting human health, animal health, food, plant and environment eco-systems in numerous ways, and many of these impacts could affect antimicrobial resistance.
3. Evidence suggests that changes occurring in the natural environment due to the climate crisis are increasing the spread of infectious disease, including drug-resistant infections.
4. High usage of antimicrobial drugs across sectors exacerbates antimicrobial resistance. The increasingly severe impacts of the climate crisis, such as more frequent and severe extreme weather events, will likely result in an increased use of antimicrobial drugs in humans, animals and plants.
5. As these two crises continue to grow, the impacts on economies, lives, and livelihoods are expected to be significant and devastating, particularly for low-and middle-income countries and small island developing states.
6. More financing, political advocacy and coordinated global action are needed to better understand and respond to the converging threats of antimicrobial resistance and the climate crisis before it is too late.
7. **The links between antimicrobial resistance and the climate crisis have been neglected and require significantly more attention, including in national action plans on antimicrobial resistance. There is currently no global initiative focused specifically on the intersection of these two crises.**

Three approaches

AMR is an extremely broad, interrelated and complex problem. It needs to be addressed at different levels and in a holistic, systemic manner.

In this study, three different approaches are described to address AMR. These different approaches complement each other and already co-exist with importance in the order they are presented below. If our focus remains on the problem-solving approach, we may find our well-intended actions making things even worse. If we put our focus on only one specific aspect, we may see other problems arising elsewhere.

Addressing the complex problem of AMR requires the broader picture, including understanding of the root causes and approaching it in a holistic way.



Stop the **COVID-19 pandemic** from becoming an **AMR catastrophe**

World Health Organization
REGIONAL OFFICE FOR Europe

Shared responsibility to prevent drug-resistant infections from becoming the next global public health emergency

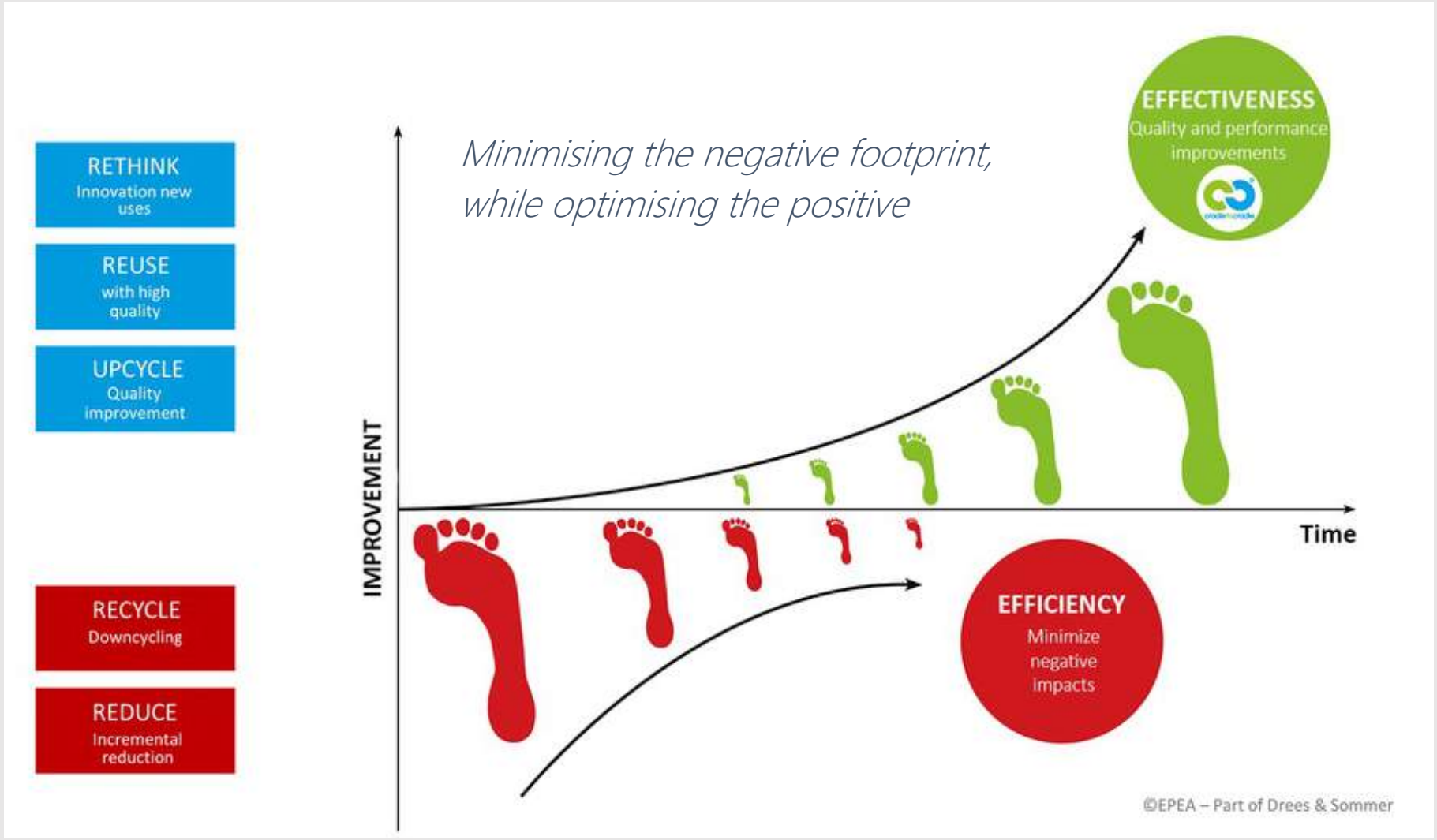
AMR is strongly interlinked with the current health crisis, climate crisis, ecological crisis and food system

therefore, requires an integrated and systemic approach

We are not moving fast enough

There is a lot more we can do!

From eco-efficiency to eco-effectiveness



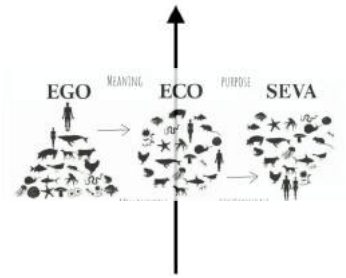
We are very dependent on natural resources – and they are running out

Biodiversity loss results in loss of our stable system as base

It must and can be done differently by creating synergistic relationship between ecological and economic systems

FROM MORE TO BETTER

Beyond Sustainability: Designing Regenerative Cultures



Living Systems Design
Pays attention to quality & quantity
Effectiveness- doing the right thing
Informed by a Systems View of Life
Thinking in patterns and principles

Positive Synergies

GHG capture
Biodiversity Increase
Water, Soil and Air-quality increase
Human Health
Quality of life

The SDGs as a bridge towards regeneration?

Natural System Tolerance

And other natural resources

Depletion fossil energy stocks

Degenerative Development

Climate
Biodiversity
Water
Soil
Air

Regenerative Development

Using renewable energy flows

Design of Technical Systems
Values only the quantifiable
Efficient - doing things right
Informed by Mechanism & Technology
Siloed & fragmented thinking

Natural Resources
Agroforestry
Food Forests
Circular system
Nature Inclusive

Agroecology
Permaculture

Conventional	Green	Sustainable	Restorative	Regenerative
(staying within the law)	(a little less negative impact)	(adding no additional harm)	(humans doing things to nature)	(humans doing things as nature)

Degenerative Cultures — **Regenerative Cultures**

Based on Reed, 2006 & Roland, 2018

Graphic adapted from Ethan Roland 2018 by Daniel C. Wahl (I added some more descriptors and also the SDGs

1. Control of disease & AMR

Protection

Global One Health – Diseases & AMR

- Improve awareness and understanding AMR
- Pathogen identification & characterisation
- Diagnostics and responsible use of antibiotics and other treatments
- Monitoring, surveillance and reporting systems for diseases and AMR (OIE)
- Disease/AMR risk analysis process
- Action plan on AMR in Aquaculture (FAO)
- Epidemiology, biosecurity, vaccination

Focus on diseases and control

2. Sustainable Intensification

Production

Sector & Value Chain – Production & Processing

- Implementation of BMP (basic water quality!) and sustainable certification
- Increase production efficiency
- High quality feed & seed (genetics)
- Large-scale efficient monoculture
- Reduction and reuse of waste, circular systems
- Recirculating Aquaculture Systems (RAS)
- Water quality in the production system
- Microbial management & zero an
- Reduce GHG-emission
- Digital technology, Smart-farming

Focus on realistic advantages in a Bus

3. Nature-positive production

Prosperity

Food – ve System

- Effectiveness, r
- Increase biodiv bial, species, area) for resilie
- Diversification uction
- Diversification
- Improve water . IMTA)
- Regional appro es
- Carbon-negative, address climate change

cal community development

mbiotic relationships

silient production and financial status

cial: Gender, fair price for the farmer

mbiotic effects: public health, flood protection d much more!

Link with the SDG's and beyond in a Value case

These 3 approaches are all necessary and currently already co-exist

1. Control of disease & AMR

2. Sustainable Intensification

3. Nature-positive production

1. Protection

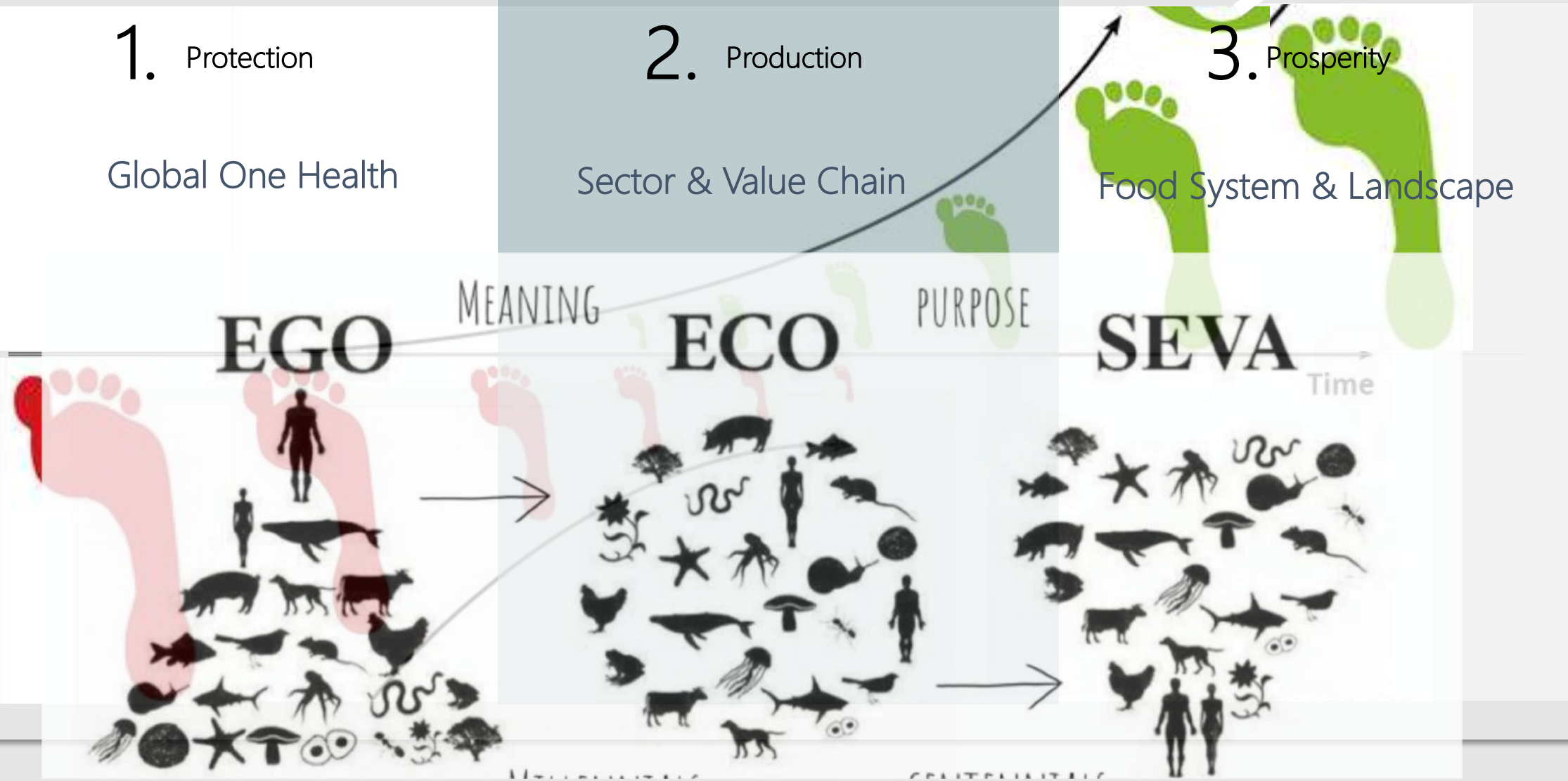
2. Production

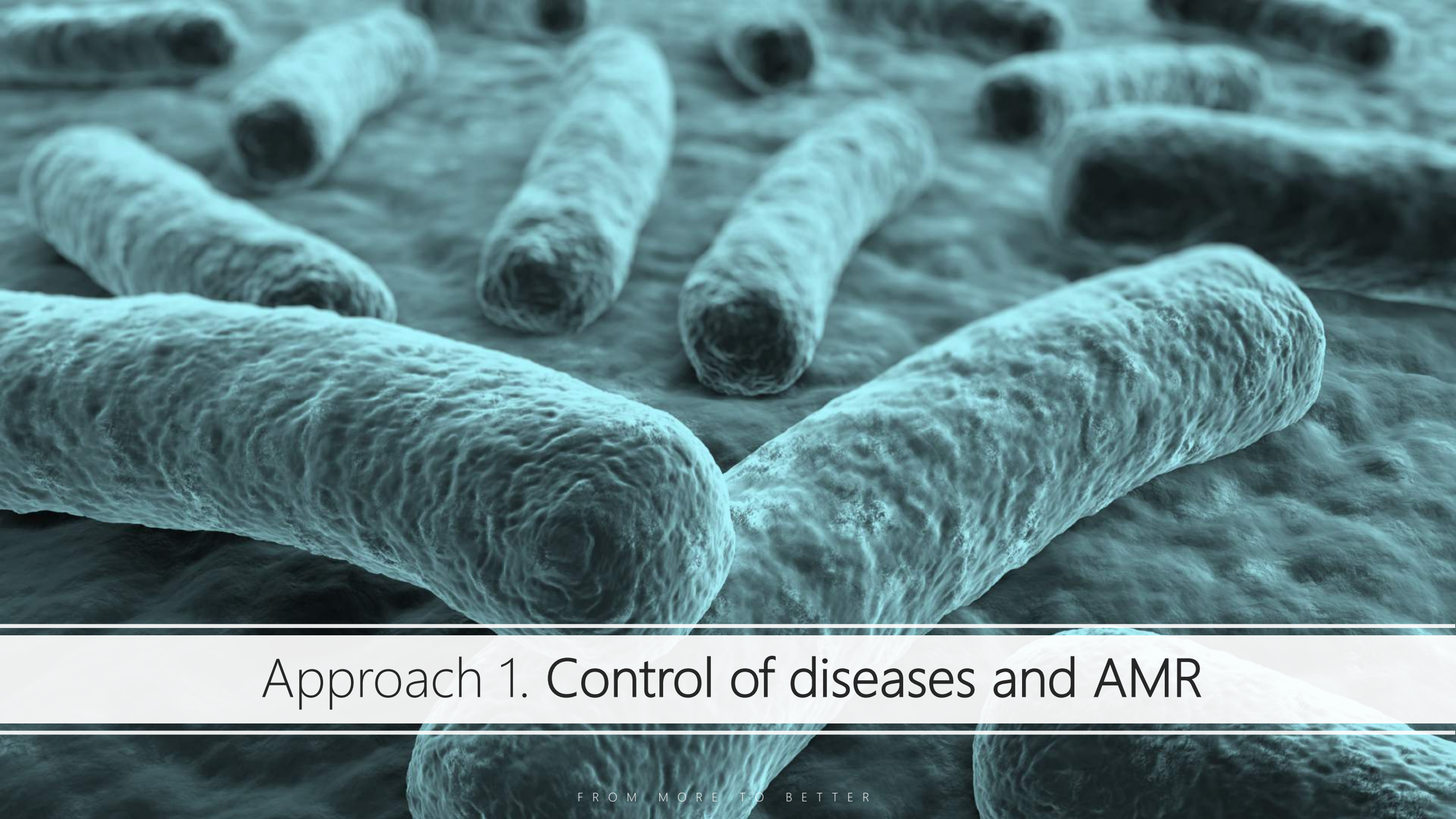
3. Prosperity

Global One Health

Sector & Value Chain

Food System & Landscape





Approach 1. Control of diseases and AMR

1. Control of diseases & AMR

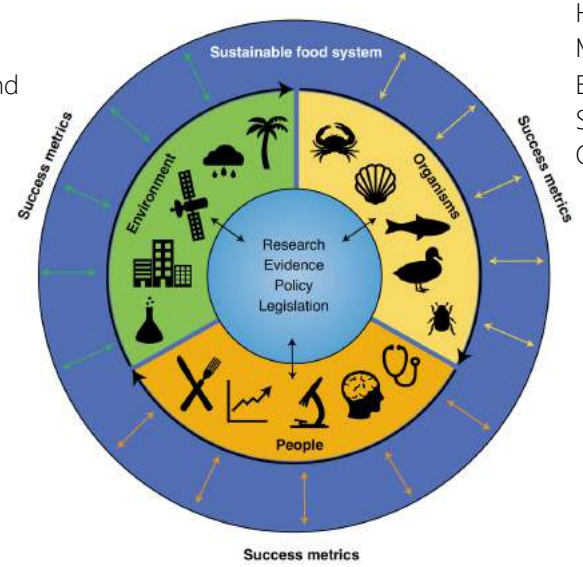
Disadvantages:
Losses already occurred, new diseases will emerge and problems will increase

Example
Approach 1

One Health Approach

National Action Plan on AMR

Environment
Optimal water usage
Optimal water quality
Protected biodiversity and natural capital
Low-energy production
Low spatial footprint



Organism
Healthy stock
Minimal chemical hazards
Biosecure farms
Safe farms
Optimized farm systems

People
Nutritious and safe food
Equitable income generation
Gender equalization
Quality employment
Knowledge and skills generation

Early detection, prevention and control

Implementation of the One Health Framework is key to addressing AMR.

The six priority areas of India's NAP-AMR include awareness, surveillance, infection prevention & control, optimizing the use of antimicrobials, research, innovation & financing, and regional leadership by India.

Multi-stakeholder approach coupled with large investment in research, rapid testing and surveillance is required for the implementation of the One Health approach

Example
Approach 1

Disease surveillance in Aquaculture

Notice trends to anticipate

REVIEWS IN Aquaculture

Reviews in Aquaculture (2021) 13, 1469–1487 doi: 10.1111/raq.12530

A 12-point checklist for surveillance of diseases of aquatic organisms: a novel approach to assist multidisciplinary teams in developing countries

Melba G. Bondad-Reantaso[1], Nihad Fejzic[2], Brett MacKinnon[1], David Huchzermeyer[3], Sabina Seric-Haracic[2], Fernando O. Mardones[4], Chadag Vishnumurthy Mohan[5], Nick Taylor[6], Mona Dverdal Jansen[7], Saraya Tavornpanich[8], Bin Hao[1], Jie Huang[9], Eduardo M. Leaño[9], Qing Li[10], Yan Liang[10] and Andrea Dall'occo[1]

1 Fisheries Division, Food and Agriculture Organization of the United Nations, Rome, Italy
2 Veterinary Faculty, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
3 Department of Ichthyology and Fisheries Science, Rhodes University, Lyndenburg, South Africa
4 School of Veterinary Medicine, Pontifical Catholic University, Santiago, Chile
5 Sustainable Aquaculture, WorldFish, Penang, Malaysia
6 Centre for Environment Fisheries and Aquaculture Science, Dorset, UK
7 Department of Laboratory Science and Technology, Norwegian Veterinary Institute, Oslo, Norway
8 Department of Aquatic Animal Health and Welfare, Norwegian Veterinary Institute, Oslo, Norway
9 Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

A methodological approach and guidance for a multidisciplinary team; the 12-point checklist showing the steps, their descriptions and the criteria and elements required to complete each step.

Where Dutch parties could contribute

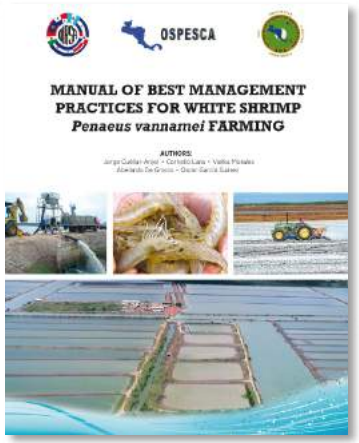
Surveillance and research to design programmes to minimize and contain AMR and monitor effectiveness is needed

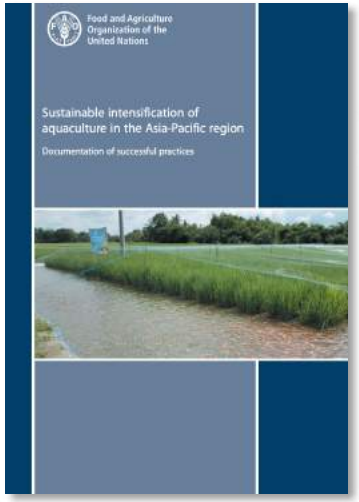
All countries need to be enabled, empowered and incentivized to transform awareness of AMR risks into action

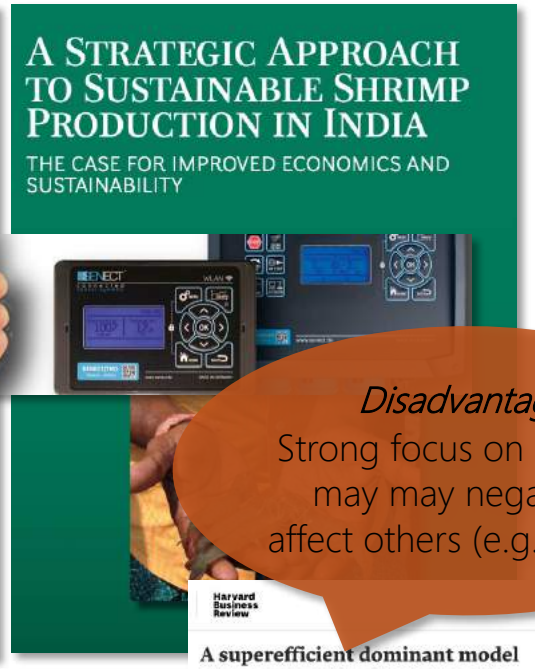
AMR Insights a a Dutch-based Global platform to address these needs

Approach 2. Sustainable Intensification

2. Sustainable intensification







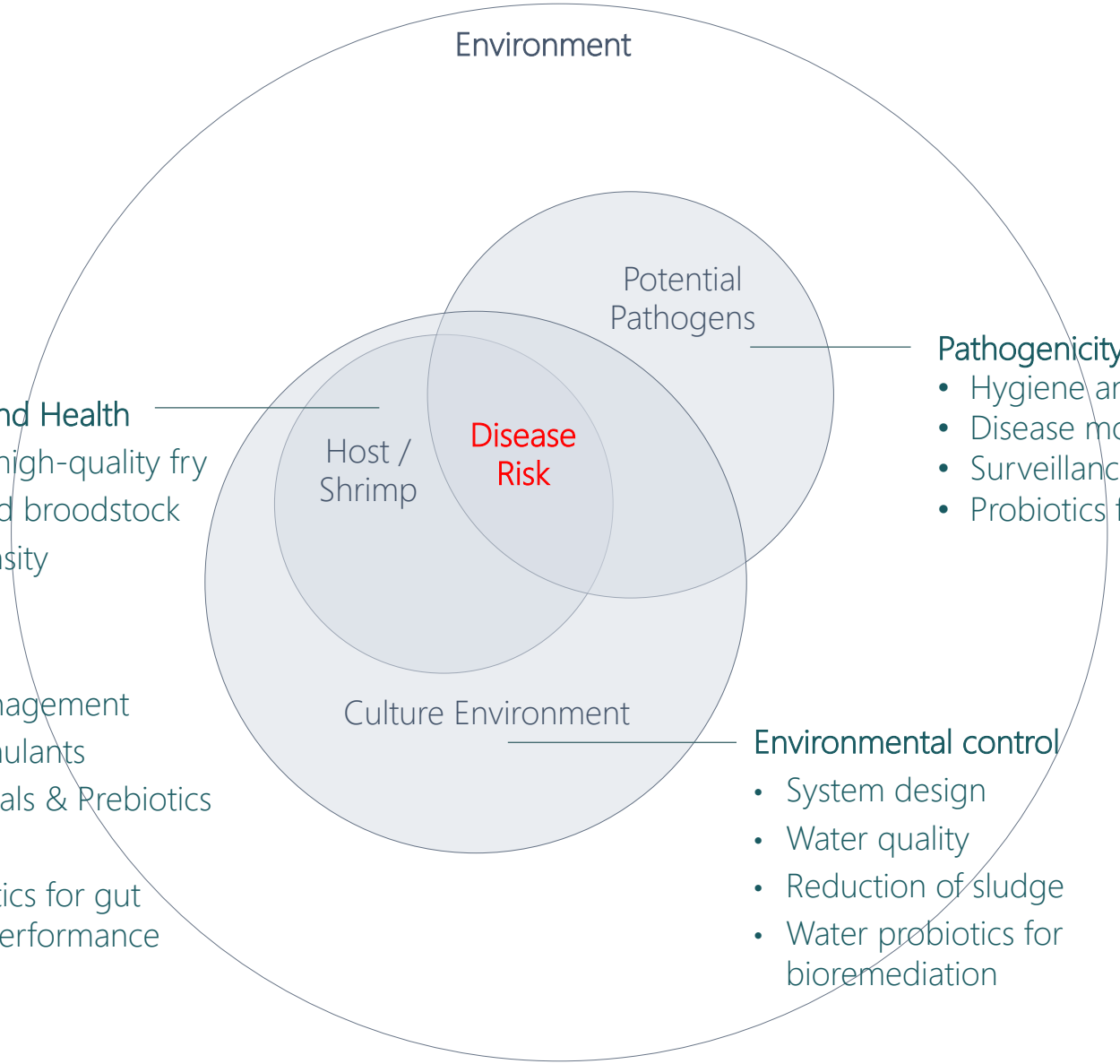
Disadvantage:
Strong focus on 1 aspect may may negatively affect others (e.g. energy)

Where Dutch parties could contribute

Best Management Practices

Training is required in all areas

The **Dutch Aquaculture Experts** (DAE) and other Dutch companies can address these needs



Performance and Health
- Selection of high-quality fry
- Domesticated broodstock
- Stocking density
- Handling
- Feed quality
- Feeding management
- Immune stimulants
- Neutraceuticals & Prebiotics
- (Vaccination)
- Feed probiotics for gut health and performance

Pathogenicity
- Hygiene and Biosecurity
- Disease monitoring, diagnosis
- Surveillance system
- Probiotics for Vibrio control

Environmental control
- System design
- Water quality
- Reduction of sludge
- Water probiotics for bioremediation

Example
Approach 2

Sustainable Intensification without the use of antibiotics

*Example **shrimp production Vietnam***

Proven benefit:

Dr. Loc (ShrimpVet Vietnam) has found that antibiotic-free production has made his results much more consistent

Start with pathogen-free hatchery production through better water treatment, biosecurity measures and diagnostics

Improve pond management through sludge removal, water and effluent treatment by making use of probiotics

Keep animals healthy through quality feed and maintain a healthy gut microbiota by applying active probiotics for microbiome moderation; vibrios will cause less damage

Example
Approach 2

Sustainable Intensification without the use of antibiotics

Example shrimp production Ecuador

Example
Approach 2

Sustainable Intensification without the use of antibiotics

Example Aquaculture Norway

Antibiotic use in the Norwegian salmon sector vs salmon production levels 1981-2020

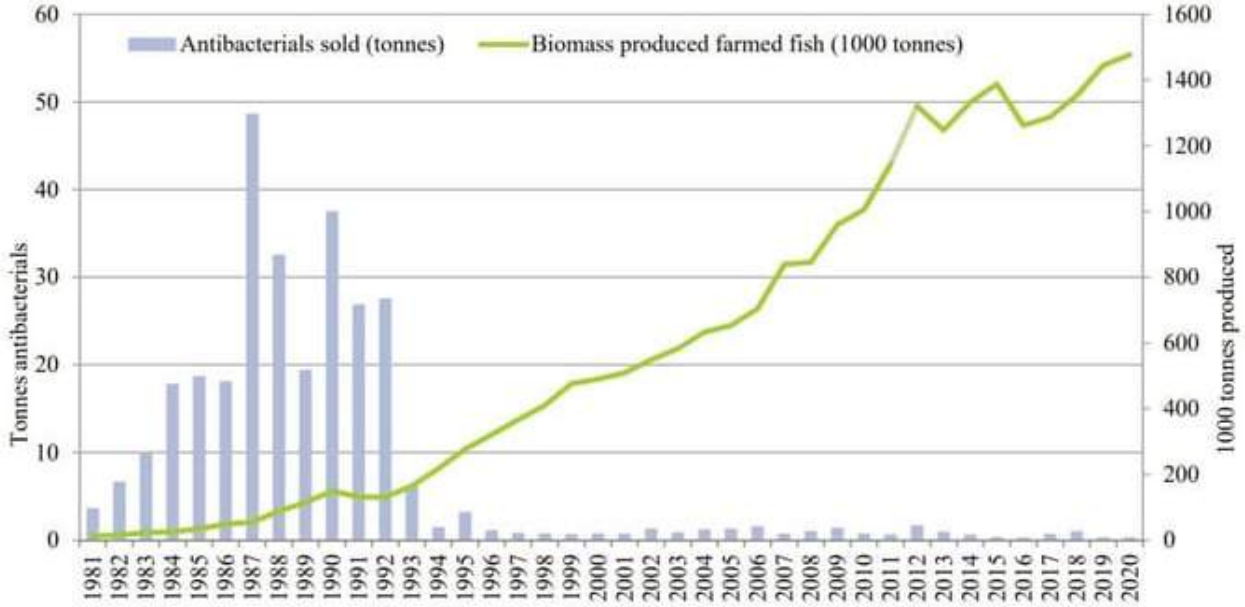


FIGURE 8. Sales, in tonnes of active substance, of antibacterial veterinary medicinal products for therapeutic use in farmed fish (including cleaner fish) in Norway in 1981-2020 versus tonnes produced (slaughtered) farmed fish. For the years 1981-2012 the data represent sales data provided by Norwegian Institute of Public Health; for 2013-2020 data represent prescription data obtained form the Veterinary Prescription Register. Data on slaughtered biomass farmed fish were obtained from Norwegian Directorate of Fisheries (https://www.fiskeridir.no/Akvakultur/Tall-og-analyse/Akvakulturstatistikk-tidsserier).

At the start of aquaculture production in Norway over 30 years ago, antibiotics were commonly used as well.

Nowadays, veterinarians, fish farmers and feed producers are legally obligated to report antibiotics use and prescriptions to a government agency, which is publicly available.

In 2020, the lowest ever number of veterinary antibiotic treatment prescriptions – just 48 in total – required by Norwegian fish farms, meaning that 99 percent of Norwegian salmon were never treated with any form of antibiotic.

This trend can be used as example for other aquaculture production areas, and for shrimp farming in India in particular.

Example
Approach 2

Sustainable Intensification without the use of antibiotics

Land animal production and Agriculture

nature plants

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nature › nature plants › letters › article

Published: 01 March 2017

Reducing pesticide use while preserving crop productivity and profitability on arable farms

Martin Lechenet, Fabrice Dessaint, Guillaume Py, David Makowski & Nicolas Munier-Jolain

Nature Plants **3**, Article number: 17008 (2017) | Cite this article

8799 Accesses | **139** Citations | **813** Altmetric | Metrics

Abstract

Achieving sustainable crop production while feeding an increasing world population is one of the most ambitious challenges of this century[1]. Meeting this challenge will necessarily imply a drastic reduction of adverse environmental effects arising from agricultural activities[2]. The reduction of pesticide use is one of the critical drivers to preserve the environment and human health. Pesticide use could be reduced through the adoption of new production strategies[3–5]; however, whether substantial reductions of pesticide use are

REUTERS

ENVIRONMENT

Only 60 Years of Farming Left If Soil Degradation Continues

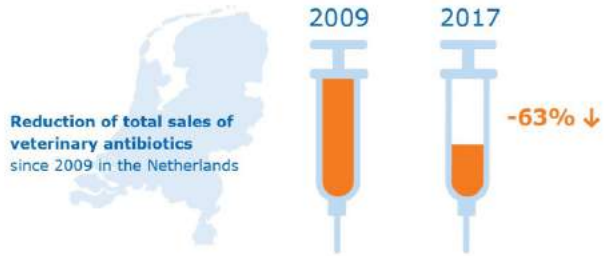
Generating three centimeters of top soil takes 1,000 years, and if current rates of degradation continue all of the world's top soil could be gone within 60 years, a senior UN official said

December 5, 2014

Banning antibiotics, reducing resistance, preventing and fighting infections

White Paper on research enabling an 'antibiotic-free' animal husbandry

Met Nederlandse samenvatting: Intensieve veehouderij zonder antibiotica



Without deviation from the long-term trend in average production and economic results in these sectors

International cost competitiveness of Dutch broiler and pig farms is not hampered by the reduction in antibiotic usage

Example
Approach 2

Sustainable Aquaculture

Aquaculture villages in Indonesia

English 中文 (Chinese) Deutsch (German) Español (Spanish) Français (French) Bahasa Indonesia (Indonesian) Italiano (Italian) 日本語 (Japanese) Br (Hindi)

MONGABAY
NEWS & INSPIRATION FROM NATURE'S FRONTLINE

RAINFORESTS OCEANS ANIMALS ENVIRONMENT BUSINESS SOLUTIONS FOR KIDS DONATE IMPACT MORE

Mongabay Series: Indonesian Fisheries

Indonesia aims for sustainable fish farming with 'aquaculture villages'

by **Luh De Suriyani, M Ambari** on 7 January 2022 | Adapted by **Basten Gokkon**

Circular shrimp ponds are increasingly being used by small-scale farmers and entrepreneurs in Indonesia. Image courtesy of the Indonesian Ministry of Marine Affairs and Fisheries.

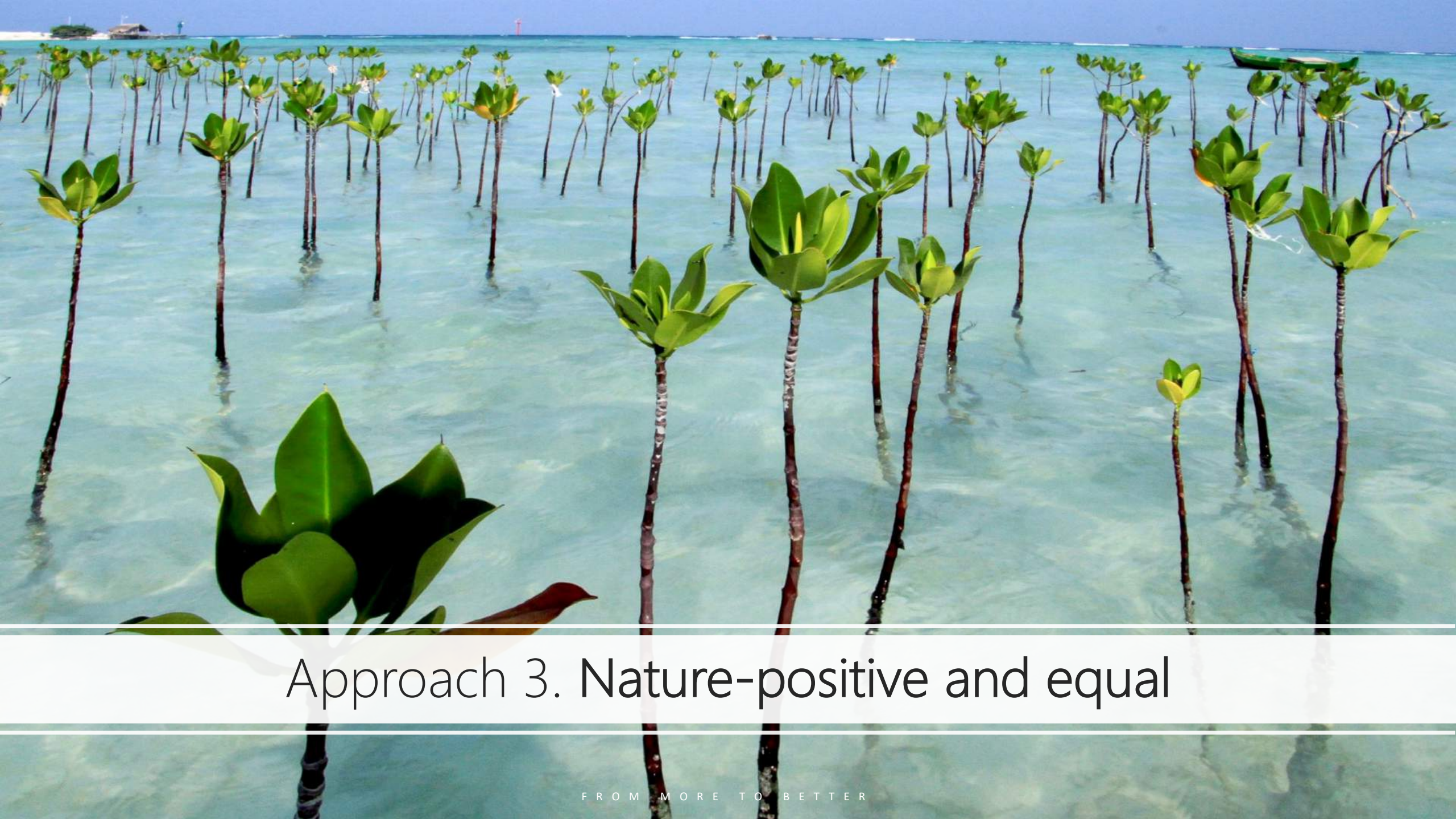
The Indonesian government plans to have a network of dozens of villages with aquaculture farms by the end of 2022

- Indonesia plans to have a network of 136 villages dedicated to aquaculture by the end of this year
- The initiative is part of the government's efforts to boost exports of its world-renowned aquaculture commodities, namely shrimp, lobster, crab and seaweed
- Experts have welcomed the plan, but say it must be supported by sound environmental planning, particularly avoiding the clearing of mangrove forests and ensuring proper waste management
- Indonesia is one of the top exporters of farmed seafood, but fish farming in the country has long come at the expense of carbon-rich mangrove forests and other important coastal ecosystems

Example
Approach 2

Sustainable Aquaculture

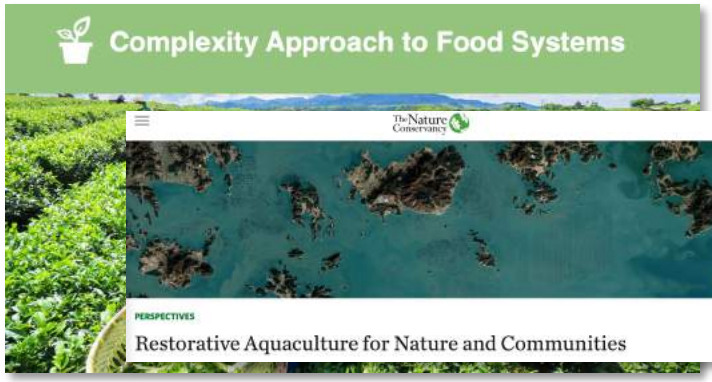
Microbial Management and Integrated production systems (Sorgeloos, 2021)

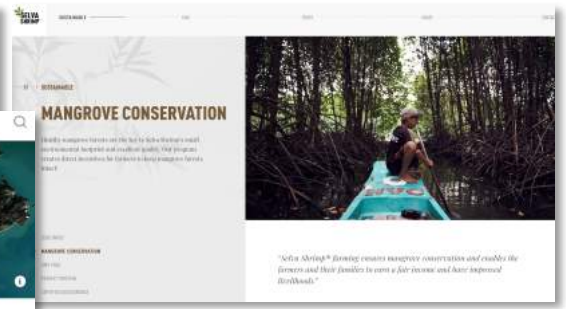


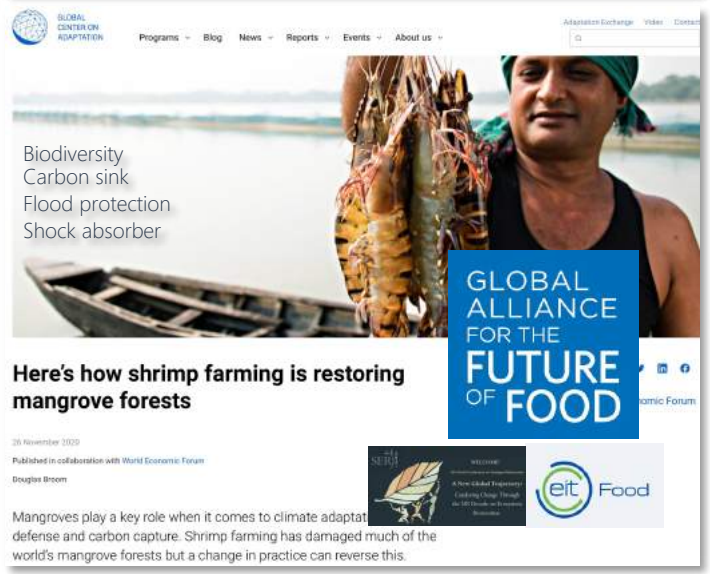
Approach 3. **Nature-positive and equal**

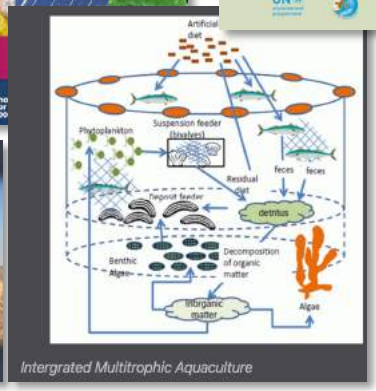
3. Nature-positive production while reducing inequalities

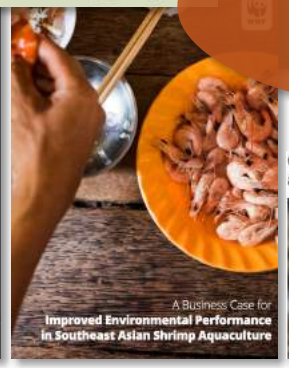
The economic and social value of nature and biodiversity are enormous









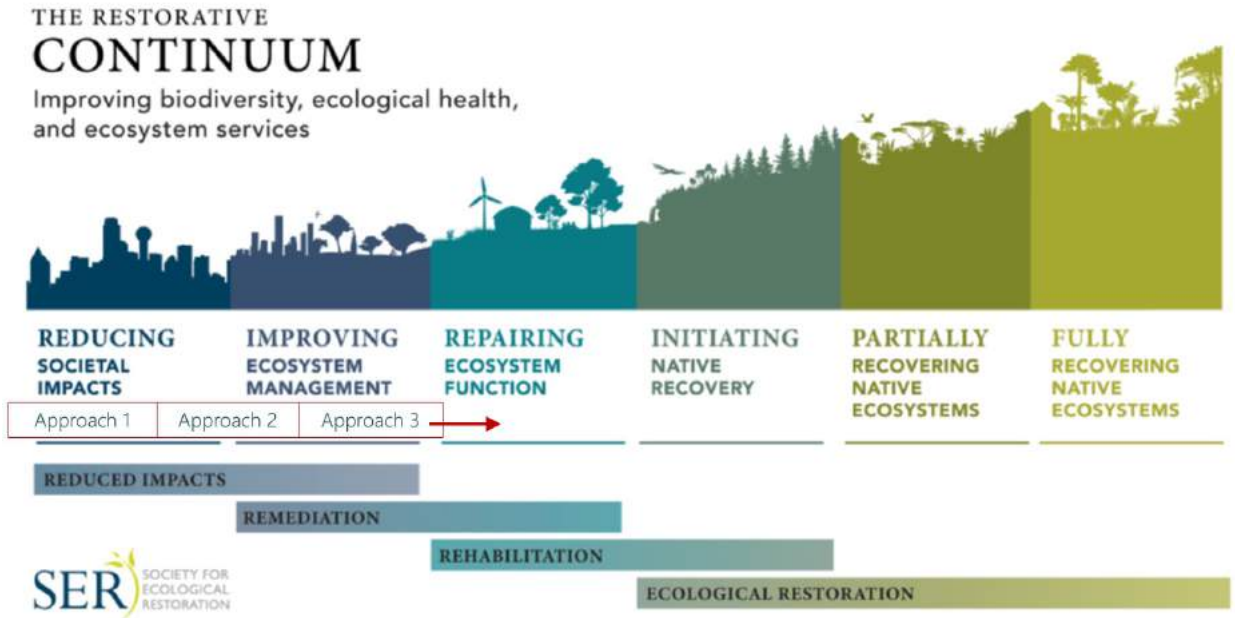


Disadvantage:
Complex and high transition costs at start

Where Dutch parties could contribute

Regenerative aquaculture can assist in the recovery of ecosystems in an area. Healthier ecosystems, with richer biodiversity, yield greater social, environmental and financial benefits.

Systems thinking is an effective approach for tackling the complex, interdependent challenge of AMR. Instead of looking at individual aspects of performance and disease in isolation, a systems approach looks at how different parts of a system interact.



Agricultural & Aquacultural intensification, efficiency and economic growth have brought us beautiful things, but we are increasingly confronted with its downside of it.

In The Netherlands, there is an increasingly number of organisations that work in a holistic way on the transition towards regenerative agriculture and believe in the long-term purpose-economy. Also consumers are increasingly willing to pay a true price for the products they buy; this includes fair price for the farmers. The government is paying for nature conservation and restoration. Business activities include social and environmental values, rather than an exclusive focus on financial returns.

This offers the opportunity to recover and improve with equal and, on the long turn, even improved production performance.

Besides AMR, antimicrobial use and human and animal health, other major global problems are addressed, such as climate change, biodiversity loss, (plastic) waste, (chemical) pollution, drinking water quality, clean air and healthy soils.

The highest form of regeneration will result in the highest leverage effect.

This transition involves collaboration with many different stakeholders, such as farmers, and their representatives, entrepreneurs in the value chain, the national government and local communities and authorities, NGO's, research, training and education institutes.

Restoration and regeneration is complex and only effective if the right practices are deployed at the right time in the right places (there are also plenty of examples which are not successful).

THE TENSION BETWEEN DIFFERENT ENVIRONMENTAL CHALLENGES, REQUIRE A HOLISTIC APPROACH IN FUNDAMENTALLY GREENING HUMANITY'S IMPACT ON THE PLANET

MONGABAY
NEWS & INSPIRATION FROM NATURE'S FRONTLINE

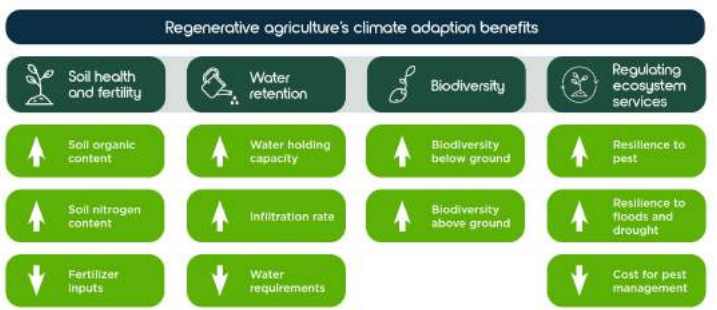
Mongabay Series: Commodity Agriculture

Conservation and food production must work in tandem, new study says

by Sheryl Lee Tian Tong on 13 December 2021

regenerative_agriculture_in_africa_report_2021.pdf

Figure 9 : Regenerative agriculture average climate adaptation benefits



Source: Vivid Economics

approaches by sharing open-source information such as crowd-sourced soil data. These advanced technologies can support agroecological approaches while corresponding to the needs of farmers in terms of adaptability, performance, and accessibility (Ajena 2018). Putting technology at the service of agroecology provides a real opportunity to enhance farming with biodiversity, through the sharing of data and knowledge development (Bellon Maurel and Huyghe 2017).

Figure 3: Agroecological approaches can be applied across geographies, production systems and scales, to guide the transition towards nature-positive production
Source: WWF, 2016 (adapted from: IPES Food, 2016; FAO 2018)

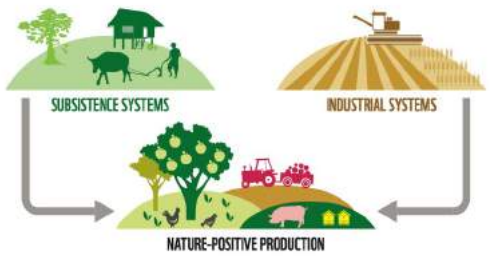
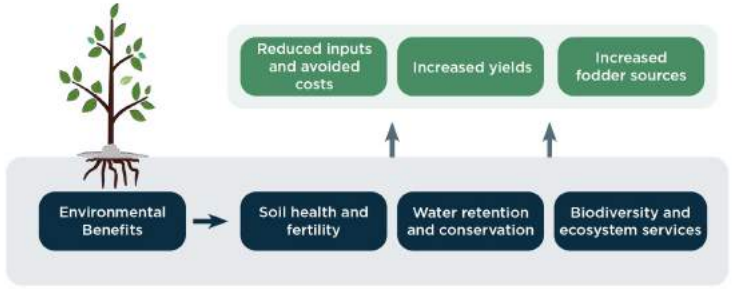


Figure 10 : Benefits of regenerative agriculture at the farmer level



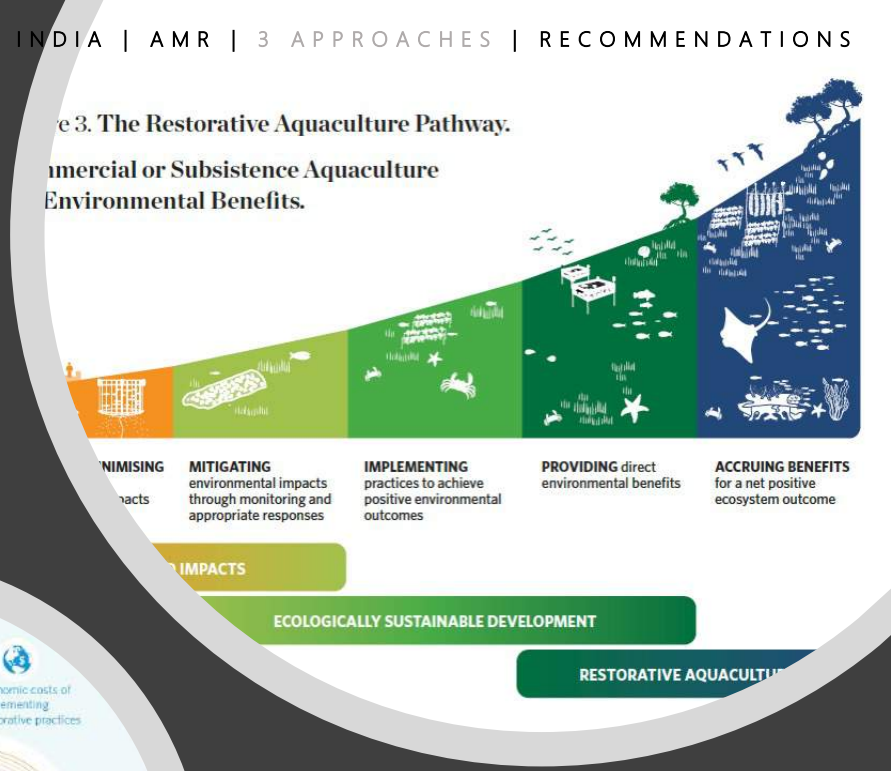
The 10 Elements of Agroecology

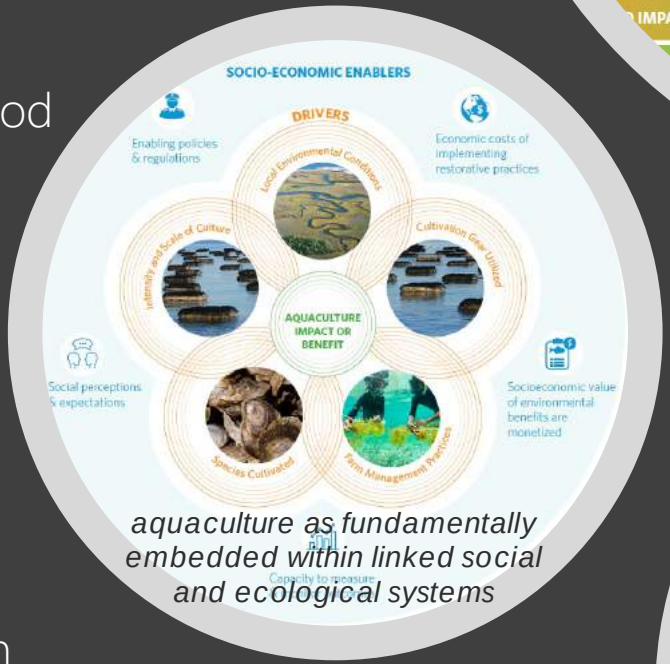
Nature-positive Aquaculture

Potential benefits

Restorative aquaculture may be one of the best opportunities to simultaneously produce healthy food and improve the health of (aquatic) environments

- Reduced risks of disease outbreaks
- Improve water quality in an area
- Increase biodiversity
- Protection from flooding
- Increase social and economic value
- Climate mitigation through carbon sequestration





aquaculture as fundamentally embedded within linked social and ecological systems

Nature-positive shrimp farming

Example Approach 3

Example Selva Shrimp in Vietnam and Indonesia

- Return Mangroves to aquaculture farms by turning the current model for farming in the area upside down: from 5% Mangrove & 95% farmland towards 60% Mangrove and 40% farmland
- Modify existing farming practices to zero-input systems (no antibiotics, no feed, no chemicals), while reversing negative impacts from decades of problematic aquaculture practices
- Triple the income for local farmers
- Introduce a sustainable, healthy, guilt-free seafood choice for consumers
- Increase the local communities' protection against sea level rise and natural disasters
- The goal is to roll out the model to larger regions, conserving and restoring 150,000ha of mangroves, while supporting a resilient local economy

Nature-positive shrimp farming in India

Example Approach 3

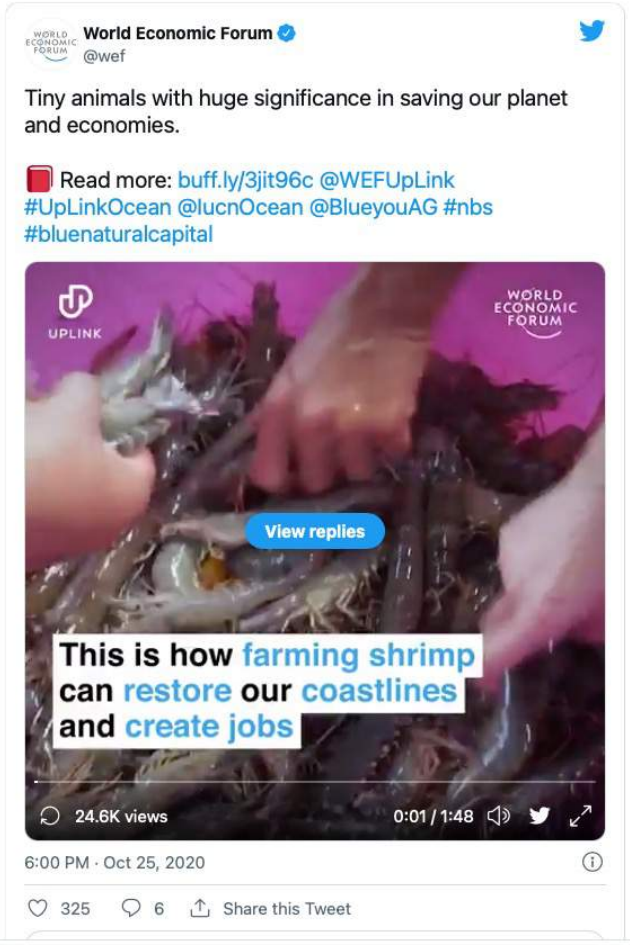
Creating healthy and resilient production systems through:

- Integrating shrimp farming with fish (tilapia) or other food production systems (e.g. rice), integrated multitrophic aquaculture (IMTA), aquaponics
- Development within the context of local ecosystem functions and services
- Spatial planning and integrated coastal zone management
- Combine shrimp farming with mangrove restoration or other (re)forestry, fisheries development and other local economic sectors
- Develop a system in combination with local community development and flood protection

Example
Approach 3

Regenerative Shrimp Farming

Shrimp production Indonesia

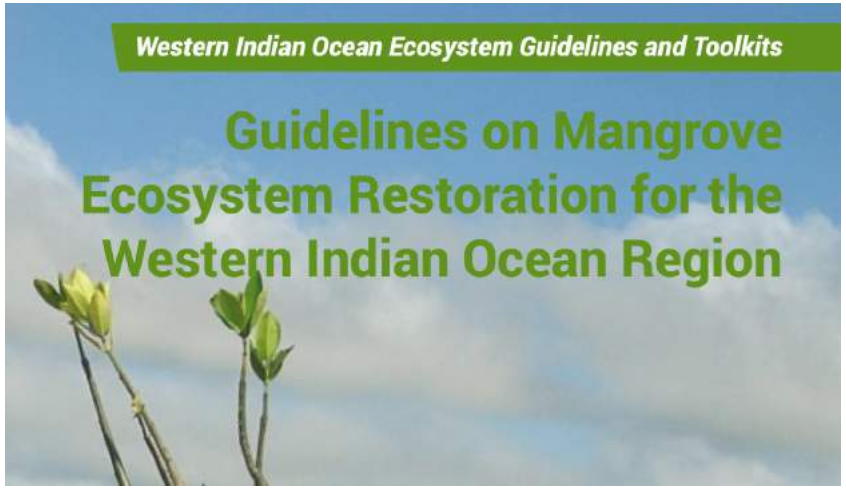


https://www.weforum.org/agenda/2020/10/shrimp-aquaculture-jobs-environment

Example
Approach 3

Regeneration of Ecosystems

Making use of experience in other areas



https://www.unep.org/news-and-stories/press-release/new-guidelines-aim-support-mangrove-restoration-western-indian-ocean

Example
Approach 3

Restorative farming

Principles, Models, Roadmaps and Opportunities

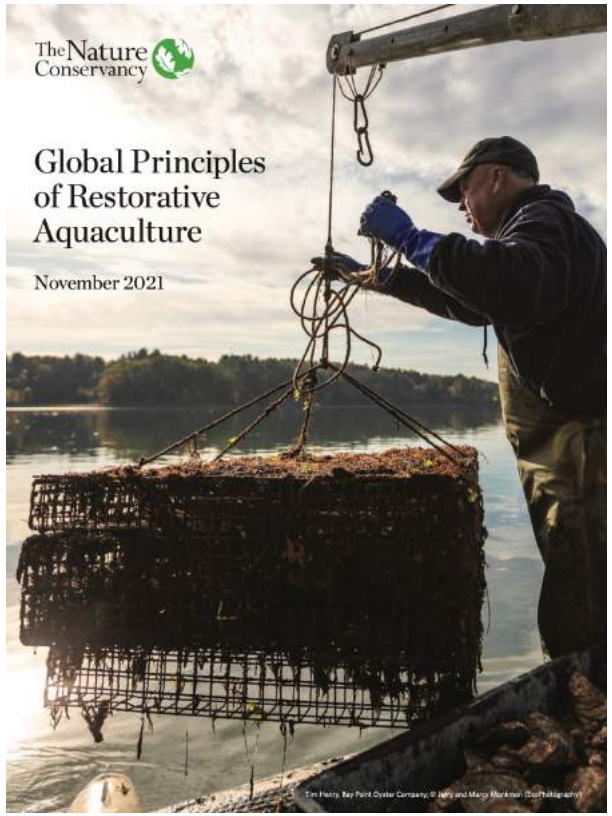
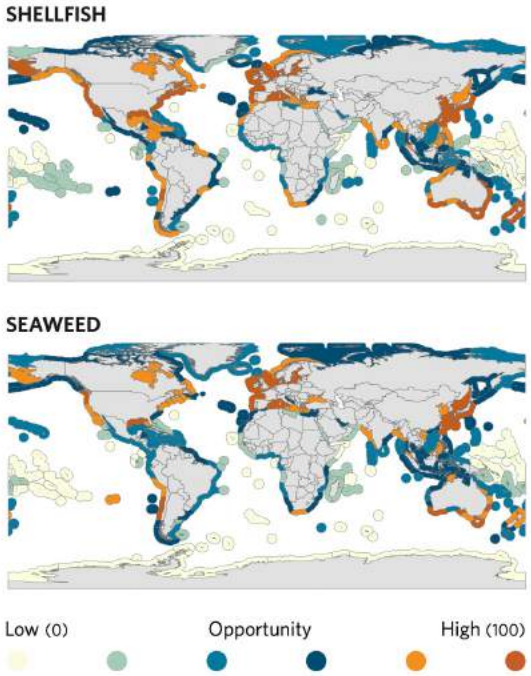


Figure 1. **Restorative Aquaculture Opportunity Index for Shellfish and Seaweed.***



*Derived from Theuerkauf *et al.* 2019

Principles of Restorative Aquaculture

01	Farms are sited where environmental outcomes are needed
02	Species are cultured that can provide the environmental outcomes intended
03	Farming equipment that enhances the delivery of environmental benefits is prioritized
04	Management practices that align with or enhance local ecological processes are adopted
05	The intensity and scale of culture works to enhance ecosystem
06	The socio-economic value of the environmental benefits provided are recognized

The Nature Conservancy

https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_PrinciplesofRestorativeAquaculture.pdf

Example
Approach 3

Building with Nature

Paradigm shift in water infrastructure solutions in Indonesia

Demak – Dream (BwN Vision) scenario – 2030

Demak – Business as usual scenario – 2030

PART III

Recommendations

Overview of Dutch businesses and parties to contribute

1. Disease & AMR control

2. Sustainable Intensification

3. Nature-positive production

Initiatives directly or indirectly involved in Aqua-meeting dd 1-10-2021

Some priority areas

	Approach	Low hanging fruit	Business 2 Business	Knowledge 2 Knowledge	Government 2 Government
1	**Global One Health** Control of diseases & AMR	Increased control of pharmaceutical production locations and their export control	Biosecurity and epidemiology Transparency of global supply chains of seafood from the aquaculture sector AND of antimicrobials from the pharmaceutical sector	Creating awareness Training on implementation of control measures of diseases and AMR Improve the operational laboratory facilities	Focus on strict control of mass production of cheap antimicrobials (incl. export to developing countries) Guidance on implementation of the National Action Plan for AMR (NAP-AMR)
2	**Sector & Value Chain – Production & Processing** Sustainable intensification in aquaculture production	Reduce unnecessary losses (diseases) by Best Management Practices - improve hygiene and DO-measurement Aiming at zero-use of antibiotics in shrimp farming	Efficient production systems, circularity, smart farming, environmental and microbial management (e.g. probiotics)	Training to farmers with focus on health management and disease prevention Research into *realistic* new production systems and area-based management (remote sensing)	Regulate the over-the-counter access to antibiotics Zero-tolerance for antibiotic use in aquaculture, and shrimp farming in particular Implementation of the SDG's
3	**Food System & Landscape – Regenerative and inclusive systems**	Critical thinking about sustainability and avoid greenwashing	Collaborations, define common long-term goals for continuous improvement Build further on business trust Prioritise fair price for the farmers	Research and training in systems thinking and approach to apply it in the complex system, where aquaculture, and shrimp farming in particular, are part of	Ethics in the pharmaceutical industry Increase diversity & biodiversity in aquaculture production Improve quality of life

However, multi- and inter-sectoral collaboration is essential in all areas

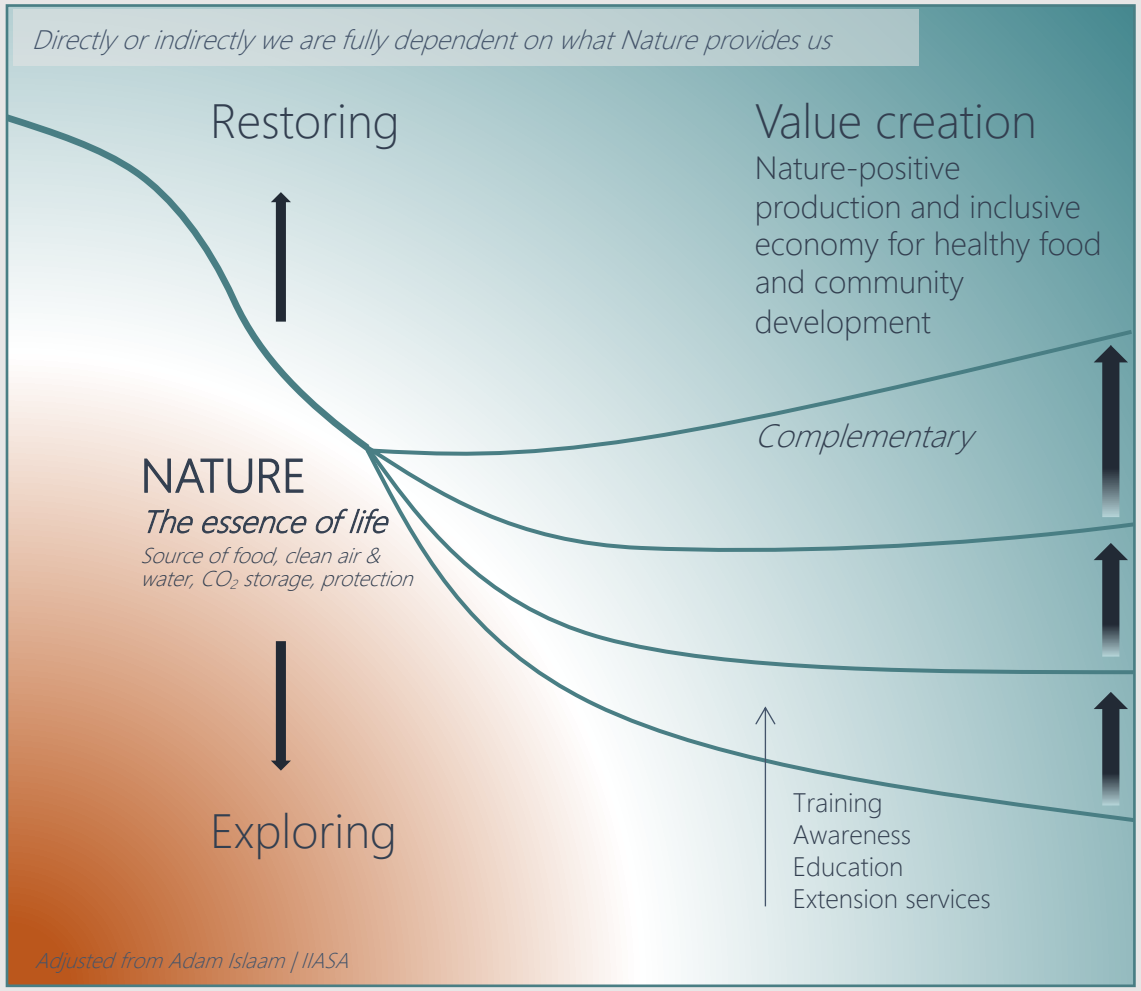
Bending the curve with Aquaculture

Aquaculture is in the unique position to be hindered by disease outbreaks, to contribute to AMR, waste and pollution, greenhouse gas emissions, biodiversity loss, to be hindered by climate change, but is also in the position to offer a solution

Not with the focus solely on intensification - because that will often result in increasing problems - but by using nature-positive and carbon-negative systems with an eye for social aspects at the same time

The goal is no longer only about innovation, but about transformation with lasting benefits for the environment and society

Bending the curve with aquaculture



Increase biodiversity at different levels; genetics, microbial, system, area - and create resilient production systems

Environmental and Social value increase - resilience

Increase biodiversity in local ecosystems
Carbon negative/Climate positive
Improve water quality
Increase equality & quality of life

Improve production performance (neutral effect)

Reduce (unnecessary) losses by disease prevention

Responsible production & Consumption

Reduce chemicals, pollution & waste
Reduce hunger & obesities
Focus on nutritional value

Business as usual
Production increase & disease control

Disease treatment & control
Surveillance & epidemiology
Intensification
Upscaling problems

Nature-based solutions are the most effective way to address AMR

FROM MORE TO BETTER

Mainstreaming AMR into programmes for achieving the SDGs will help accelerate progress and boost resilience

Identification of impact areas in the seafood value chain in India

Ecosystem development

- Increase wetlands/mangrove areas
- Planting native trees
- Increase local biodiversity
- Local community development

Production systems

- Zero antimicrobial use
- Zero waste and pollution
- Carbon-negative production
- Price-premium/fair price for the farmer
- Resilient production systems

Processing & Export

- Full traceability
- Gender
- Fair wage for workers

Import & Trade

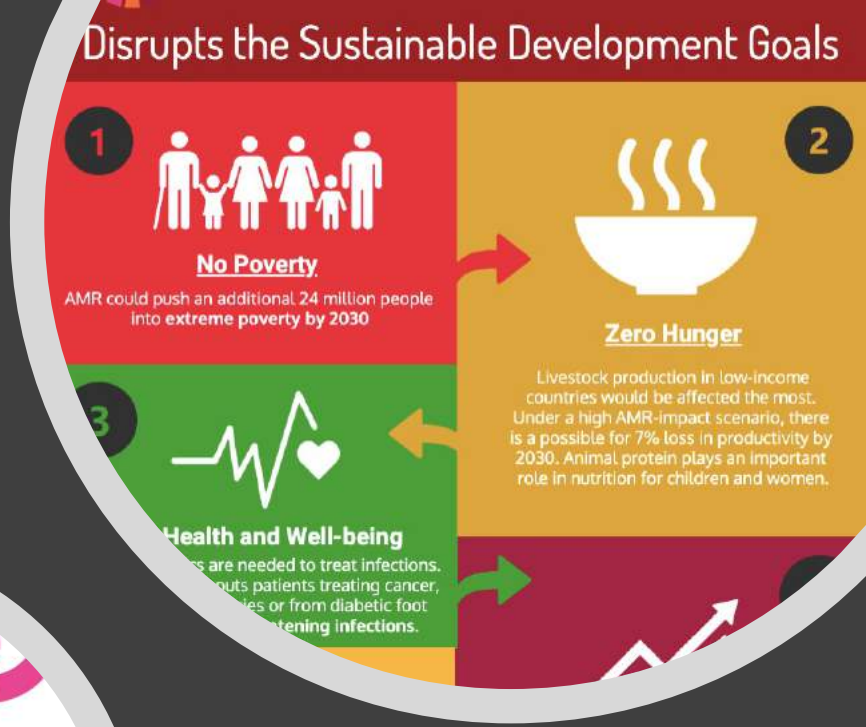
- Trust
- Transparency
- Purpose economy

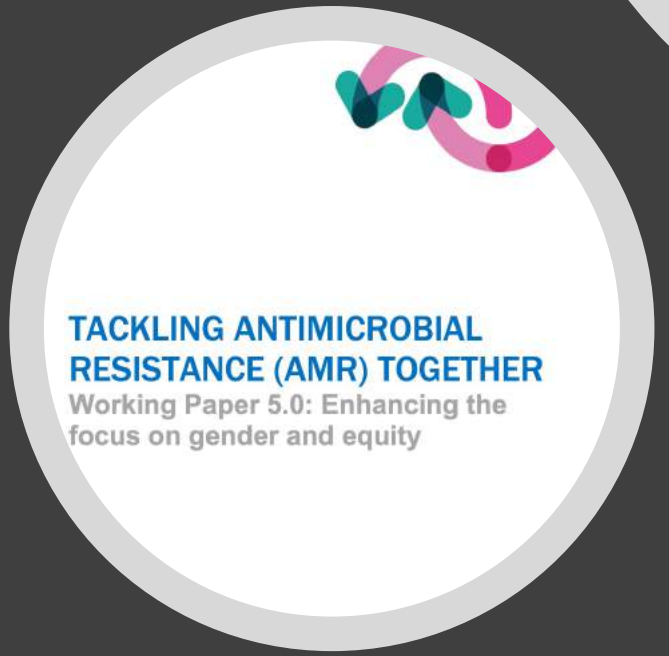
Consumer information

- Story telling and its implementation
- Training/ Awareness creation
- AVOID Greenwashing

Aquaculture has the potential to have positive but also negative impacts on people and the environment, and thus we need to maximize positive impacts and minimize negative impacts in all steps in the production and value chain

Regenerating landscapes and water bodies and revitalizing communities offers tremendous opportunities for society and business





Re-think business development

With new alarming reports on AMR and other global issues increasingly coming up, there is a strong need to bring business and governments into contact with a new economic model in which not only financial returns count, but also social and ecological values have meaning.

From Business case to Value case

Given the systemic issues society faces, we must think beyond Shareholder Value – and even Shared Value – to measure all of the ways in which a business can *Create System Value*

Shareholder Value

Financial returns are all that matters: companies privatize gains and externalize losses.

Shared Value

Business comes first: negative impacts are often not sufficiently internalized, or are justified by 'doing good' elsewhere.

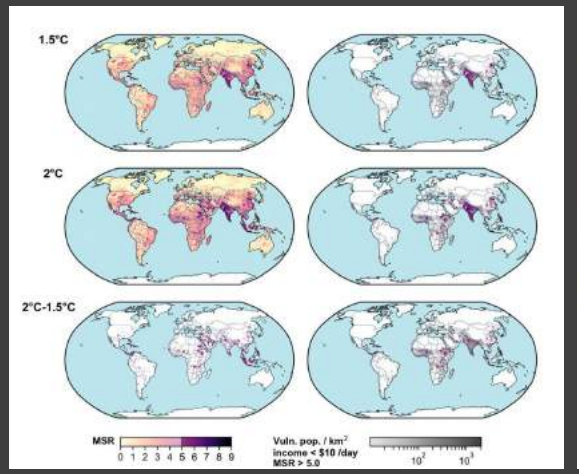
System Value

Business in no way hinders – and ideally contributes to – society's progress toward future-fitness.

Companies that included environmental and social goals already proved to have better financial results

Creating win-win situations

The aim is not maximisation of production output through intensification, but addressing the major global challenges in all our activities



NEWS | 05 November 2021

Scientists cheer India's ambitious carbon-zero climate pledge

India's 2070 goal could help limit global warming to 1.5 °C, say researchers – but it will require the nation to juggle steep emissions cuts with lifting a significant proportion of its population out of poverty.

Gayathri Vaidyanathan

Indian Prime Minister Narendra Modi speaks at the COP26 meeting in Glasgow. Credit: Jeff J Mitchell/Getty

India, the world's third-biggest emitter of greenhouse gases, has pledged to achieve net-zero carbon emissions by 2070. The ambitious commitment, made on 1 November at the high-stakes COP26 climate meeting in Glasgow, UK, brings India in line with other big emitters, including the United States, China, Saudi Arabia and the European Union, which have made similar promises.

The whole is greater than the sum of its parts

Environmental – Social – Financial

Summary & Conclusions

Part I
Trends and developments for AMR from Aquaculture

- Aquaculture is the most diverse food producing sector (in species and production systems) and has been the fastest growing in the past 4 decades
- Aquaculture production will continue to increase – export of seafood from India to EU/NL as well
- The biggest problems experienced by the growth of the aquaculture industry are related to the fish and shrimp diseases
- At current rates, global antimicrobial consumption in aquaculture is expected to increase 33% between 2017 and 2030 (Schar *et al.*, 2020)
- AMR is one of the biggest threats to global health, food security and development today (WHO) – and will increase
- AMR is linked to other critical agendas such as climate change, environmental degradation, biodiversity loss and global human health
- AMR is complex, requires shared responsibilities, an integrated systems approach and rapid and effective action

Part II
Approaches to reduce AMR in India

- Continuously new alarming reports are published about global limits being increasingly exceeded
- AMR is one of these global challenges and and cannot be seen as a separate issue
- This study outlines three approaches to address AMR in the Indian seafood sector; 1. Control, 2. Sustainable Intensification and 3. Nature Positive and Socially Inclusive
- The 3 approaches are all necessary and currently already co-exist in the order of importance in which they were presented (1→2→3)
- Much effort is put on diseases control and AMR surveillance in the One Health Approach
- Sustainable intensification with implementation of BMP and focus on healthy production animals are essential for further development of the Indian aquaculture sector – the use of antimicrobials is not needed

Part III
Recommendations

- AMR can be addressed more effectively when the order of focus is shifted towards approach 3→2→1
- There is still a limited number of initiatives related to nature-positive, carbon-negative and inclusive aquaculture production areas
- Make use of ecosystem benefits of aquaculture; nature-positive and carbon-negative with more focus on polyculture, IMTA, mangroves, bivalve and seaweed production
- It is much faster, easier and cheaper than fixing problems afterwards
- The big gain lies in the synergistic effects – the whole is greater than the sum of its parts

Options for the way ahead together

- Continue with the One Health approach on disease knowledge, diagnosis, surveillance systems, also for AMR
- Aiming at zero use of antibiotics in shrimp farming (responsible use for other sectors)
- Make use of proven technologies for local development on systems, digital technologies, genetics
- Promote only the *realistic* advantages of new technologies and focus on effectiveness
- Improve local capacity building on resilient production systems and innovation
- EU/NL is asking for sustainable Seafood (CBI, 2021) - Increase collaboration and TRUST, sharing responsibilities on AMR ánd market with fair price for the farmers, including small-scale actors
- There are many initiatives to make the Dutch agri-food sector more sustainable and regenerative; this information and experience can be translated towards the specific situation in India

Antimicrobial Resistance

Public health

Food production

Climate change

Nature – water, air, soil

Biodiversity

Waste and pollution

Quality of life of people

are all

interconnected

Let's accept our responsibility and take the opportunity

Combining different approaches to address AMR

- in the right order
- within the right context
- in the right balance

FROM MORE TO BETTER

References

References and Websites accessed (in the period of Jan-Dec 2021)

Aich, N., Ahmed, N., & Paul, A. (2018, August). Issues of Antibiotic Resistance in Aquaculture Industry and Its Way Forward. International Journal of Current Microbiology and Applied Sciences, 7(8), 26-41. Retrieved from https://www.researchgate.net/publication/327115590_Issues_of_Antibiotic_Resistance_in_Aquaculture_Industry_and_Its_Way_Forward

Aquapost. (2020, December 30). Aquaculture certification conundrum in Indian shrimp production. Retrieved from Aqua post: http://www.aquapost.in/aquaculture-certification-conundrum-in-indian-shrimp-production-2/

Babu, B., Sathiyaraj, G., Mandal, A., Kandan, S., Biju, N., Palanisamy, S., Prabhu, N. M. (2021). Surveillance of disease incidence in shrimp farms located in the east coastal region of India and in vitro antibacterial efficacy of probiotics against Vibrio parahaemolyticus. Journal of Invertabrate Pathology, 179 (2). Retrieved from Surveillance of disease incidence in shrimp farms located in the east coastal region of India and in vitro antibacterial efficacy of probiotics against Vibrio parahaemolyticus

Bellet, C., Hamilton, L. & Rushton, J. Re-thinking public health: Towards a new scientific logic of routine animal health care in European industrial farming. Humanit Soc Sci Commun 8, 214 (2021). https://doi.org/10.1057/s41599-021-00890-y

Berg, G., Rybakova, D., Fischer, D. et al. Microbiome definition re-visited: old concepts and new challenges. Microbiome 8, 103 (2020). https://doi.org/10.1186/s40168-020-00875-0

Bondad-Reantaso, Melba, Nihad Fejzic, Brett MacKinnon, David Huchzermeyer, Sabina Seric-Haracic, Fernando O. Mardones, Chadag Vishnumurthy Mohan, Nick Taylor, Mona Dverdal Jansen, Saraya Tavornpanich , Bin Hao, Jie Huang, Eduardo M. Lea~no, Qing Li, Yan Liang and Andrea Dall'occo. A 12-point checklist for surveillance of diseases of aquatic organisms: a novel approach to assist multidisciplinary teams in developing countries. Reviews in Aquaculture 13(1), 1469-1487. DOI: 10.1111/raq.12530

Bonten, M. J., van Geijlswijk, I. M., Heederik, D. J., Mevius, E. D., & Wagenaar, J. A. (2020). Usage of Antibiotics in Agricultural Livestockin the Netherlands in 2019. Utrecht: SDa. Retrieved from https://cdn.i-pulse.nl/autoriteitdiergeneesmiddelen/userfiles/Publications/sda-rapport-usage-of-antibiotics-in-agricultural-livestock-in-2019-corr-fig5b.pdf

Brunton, L. A., Desbois, A. P., Garza, M., Vishnumurthy, C., Mohan, C. V., Häsler, B., Guitian, J. (2019). Identifying hotspots for antibiotic resistance emergence and selection,and elucidating pathways to human exposure: Application of a systems-thinking approach to aquaculture systems. Science of The Total Environment, 1344-1356. Retrieved from https://www.sciencedirect.com/science/article/pii/S0048969719327056?via%3Dihub

Cabello et al. (2016). F.C. Cabello, H.P. Godfrey, A.H. Buschmann, H.J. Dölz. Aquaculture as yet another environmental gateway to the development and globalisation of antimicrobial resistance. Lancet Infect. Dis., 16 (2016), pp. e127-e133

Chandler, C. I. (2019, May). Current accounts of antimicrobial resistance: stabilisation, individualisation and antibiotics as infrastructure. Palgrave communications, 53. Retrieved from https://www.nature.com/articles/s41599-019-0263-4

Chauhan and Singh (2019). A. Chauhan, R. Singh. Probiotics in aquaculture: a promising emerging alternative approach. Symbiosis, 77 (2019), pp. 99-113

Committee on Fisheries. (February 2021). IMPLEMENTATION OF THE FAO ACTION PLAN ON ANTIMICROBIAL RESISTANCE (AMR) 2016–2020 IN AQUACULTURE AND THE PROPOSAL OF FAO ACTION PLAN ON AMR (2021–2025). Rome: FAO. Retrieved from http://www.fao.org/3/ne476en/ne476en.pdf

Courtemanche, G., Wadanamby, R., Kiran, A., Toro-Alzate, L. F., Diggle, M., Chakraborty, D., Van Dongen, M. (2021, March). Looking for Solutions to the Pitfalls of Developing NovelAntibacterials in an Economically Challenging System. Microbiology research, 12(1), 173-185. Retrieved from https://www.mdpi.com/2036-7481/12/1/13

Critical knowledge gaps and research needs related to the environmental dimensions of antibiotic resistance. (2018, August). Environment International, 117, 132-138. Retrieved from https://www.sciencedirect.com/science/article/pii/S0160412018300989?via%3Dihub

De Schryver et al. (2014). P. De Schryver, T. Defoirdt, P. Sorgeloos. Early mortality syndrome outbreaks: a microbial management issue in shrimp farming? PLoS Pathog., 10 (2014), Article e1003919

Defoirdt,Tom, Patrick Sorgeloos, and Peter Bossier. "Alternatives to antibiotics for the control of bacterial disease in aquaculture." Current opinion in microbiology 14.3 (2011): 251-258.

Desbois, A.P., Mahmoud Eltholth, M.G., Hegazy, Y.M., Mateus, A., Adams, A., Little, D.C., Høg, E., Vishnumurthy Mohan, Shimaa E. Ali, Lucy A. Brunton (2021). Systems-thinking approach to identify and assess feasibility of potential interventions to reduce antibiotic use in tilapia farming in Egypt. Aquaculture, Volume 540, 736735, ISSN 0044-8486. https://doi.org/10.1016/j.aquaculture.2021.736735

Devi, S. (2021) Dept. of Microbiology GMC. Implementation of AMR State Action Plan– perspective from Kerala, India. https://cdn.cseindia.org/attachments/0.19716100_1605869050_sarada-devi.pdf

European Commision. (n.d.). EU import conditions for seafoodand other fishery products. Retrieved from ec.europa: https://ec.europa.eu/food/sites/food/files/safety/docs/ia_trade_import-cond-fish_en.pdf

FAO (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome.

FAO (2021). The FAO Action Plan on Antimicrobial Resistance 2021–2025. Rome.https://doi.org/10.4060/cb5545en

FAO. (2017). Antimicrobial Resistance (AMR) in Aquaculture. Rome: FAO. Retrieved from http://www.fao.org/fishery/nems/41307/en

FAO. (2020). Understanding Antimicrobial Resistance in Aquaculture. World: Asian Fisheries Society. Retrieved from

http://www.fao.org/fileadmin/user_upload/remesa/library/Undestanding%20Antimicrobial%20resistance%20in%20Aquaculturen.pdf

FIS. (2017, August 5). Exporters fear EU restrictions due to antibiotics inaquaculture products. Retrieved from FIS: www.fis.com

Fitriani, M. E. (N.D). Sustainable Supply Chain Analysis of Shrimp in Indonesia to meet European Market Demand. Wageningen University. Retrieved from https://edepot.wur.nl/458422

FIU. (2017). Monitoring and evaluation of the global action plan on antimicrobial resistance(AMR): Regional expert consultation on monitoring and evaluation of AMR interventions. (p. 40). Washington DC: Robert Stempel College of Public Health & Social Work. Retrieved from https://www.paho.org/hq/dmdocuments/2017/2017-cha-monit-eval-gapar-meeting-report.pdf

Gandra, S., Joshi, J., Trett, A., Lamkang, A. S., & Laxminarayan, R. (November 2017). Scoping Report on Antimicrobial Resistance in India. Washinton DC: Center for Disease Dynamics, Economics & Policy. Retrieved from https://cddep.org/wp-content/uploads/2017/11/scoping-report-on-antimicrobial-resistance-in-india.pdf

Garza, M., Häsler, B., Chadag, M., Brunton, L., & WIeland , B. (aug 2019). Typology of interventions aiming to reduce antimicrobial use (AMU) in aquaculture systems in low and middle-income countries. London: RVC Royal veterinary college. Retrieved from https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/3765/Garza_2019_Typology-of-interventions_Poster.pdf

Global Antibiotic Resistance Partnership (GARP) – India Working Group. Rationalizing antibiotic use to limit antibiotic resistance in India+. The Indian Journal of Medical Research. 2011;134(3):281-294.

Góchez, D., Jeannin, M., Moulin, G., & Erlacher-Vindel, E. (2021). OIE Annual Report on Antimicrobial Agents Intended for Use in Animals. Paris: OIE. Retrieved from https://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/AMR/A_Fifth_Annual_Report_AMR.pdf

Government of India. (apr 2017). National Action Plan on Antimicrobial Resistance (NAP-AMR). India: Government of India. Retrieved from https://www.ncdc.gov.in/WriteReadData/linkimages/AMR/File645.pdf

Henriksson, P. J., Rico, A., Troell, M., Klinger, H. D., Buschmann, H. A., Saksida, S., Zhang , W. (nov 2017). Unpacking factors influencing antimicrobial use in globalaquaculture and their implication for management: a reviewfrom a systems perspective. (18 nov 2017), 6. Retrieved from https://link.springer.com/content/pdf/10.1007/s11625-017-0511-8.pdf

Hertel, T., Elouafi, I., Tanticharoen, M. et al. Diversification for enhanced food systems resilience. Nat Food 2, 832–834 (2021). https://doi.org/10.1038/s43016-021-00403-9

Hinchliffe, S., Butcher, A., & Rahman, M. M. (2018, November). The AMR problem: demanding economies,biological margins, and co-producing alternativestrategies. Palgrave Communications, 4(142). Retrieved from https://www.nature.com/articles/s41599-018-0195-4

Holmström, K., Gräsland, S., Wahlström, A., Poungshompoo, S., Bengtsson, B.-E., & Kautsky, N. (2003, March). Antibiotic use in shrimp farming and implications forenvironmental impacts and human health. International Journal of Food Science and Technology, 38(3), 255-266. Retrieved from https://www.researchgate.net/publication/227620359_Antibiotic_use_in_shrimp_farming_and_implications_for_environmental_impacts_and_human_health

Indian Aquaculture for Disease Management. J Fish Aqua Dev: JFAD-129. DOI: 10.29011/JFAD-129.100029

Kraemer SA, Ramachandran A, Perron GG. Antibiotic Pollution in the Environment: From Microbial Ecology to Public Policy. June 2019. Microorganisms. 2019;7(6):180. doi:10.3390/microorganisms7060180

Kumar, R., Ng, T. H., & Wang, H.-C. (2020, Januari). Acute hepatopancreatic necrosis disease in penaeid shrimp. Reviews in Aquaculture, 12(3), 1867-1880. Retrieved from https://onlinelibrary.wiley.com/doi/epdf/10.1111/raq.12414

Kumar, S. G., Adithan, C., harish, B. N., Sujatha, S., Roy, G., & Malini, A. (2013, March). Antimicrobial resistance in India: A review. Journal of Natural Science Biology and Medicine, 4(2), 286-291. Retrieved from https://pubmed.ncbi.nlm.nih.gov/24082718/

Kumaran, M., Geetha, R., Antony, J., Vasagam, K. P., Anand, P. R., Ravisankar, T.,Vijayan, K. K. (2021, January). Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India – a sectoral assessment. Aquaculture(531). Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0044848620315891

Larsson, D.G.J., Flach, CF. Antibiotic resistance in the environment. Nat Rev Microbiol (2021). https://doi.org/10.1038/s41579-021-00649-x

Lobie, T.A., Roba, A.A. and Booth, J.A. Knut Ivan Kristiansen, K.I., Aseffa, A., Skarstad, K. and Bjørås, M. (2021). Antimicrobial resistance: A challenge awaiting the post-COVID-19 era. International Journal of Infectious Diseases 111 (2021) 322–325

Lulijwa, R., Rupia, E. J., & Alfara, A. C. (2020, March). Antibiotic use in aquaculture, policies and regulation, healthand environmental risks: a review of the top 15 majorproducers. Reviews in Aquaculture, 12(2), 640-663. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/raq.12344

Mishra SS, Das R, Choudhary P, Debbarma J, Sahoo SN, et al. (2017) Prevalence of Fish and Shrimp Diseases and Use of Various Drugs and Chemicals in

Morel, C.M., Lindahl, O., Harbarth, S. et al. Industry incentives and antibiotic resistance: an introduction to the antibiotic susceptibility bonus. J Antibiot 73, 421–428 (2020). https://doi.org/10.1038/s41429-020-0300-y

Mutua, F., Sharma, G., Grace , D., Bandyopadhyay, S., Shome , B., & Lindahl, J. (2020, July). A review of animal health and drug usepractices in India, and their possible link toantimicrobial resistance. Antimicrobial Resistance & Infection Control, 9(103). Retrieved from https://aricjournal.biomedcentral.com/articles/10.1186/s13756-020-00760-3

Navghan, M., Kumar, N. R., Gawa, S., & Hoilenting. (2017). Value Chain Analysis of Farmed Shrimp in Navsari District of Gujarat. International Journal of pure & applied Bioscience(5(6)), 352-357. Retrieved from http://dx.doi.org/10.18782/2320-7051.4013

Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Troel, M. (2021, March). A 20-year retrospective review of global aquaculture. Nature, 591(1), 551-563. Retrieved from https://www.nature.com/articles/s41586-021-03308-6

OIE wildlife health framework. (2021). PROTECTING WILDLIFE HEALTH TO ACHIEVE ONE HEALTH. Paris: OIE. Retrieved from https://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Wildlifehealth_conceptnote.pdf

Patil, P. K., Geetha, R., Ravisankar, T., Avunje, S., Solanki, H. G., Abraham, T. J., Vijayan, K. K. (2021, February). Economic loss due to diseases in Indian shrimp farming with special reference to Enterocytozoon hepatopenaei (EHP) and whit spot syndrome virus (WSSV). Aquaculture, 533. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0044848620339375

Pikkemaat, M. G., Yassin, H., van der Fels-Klerx, H. J., & Berendsen, B. J. (aug 2016). Antibiotic Residues and Resistance in the Environmen. Wageningen: RIKILT Wageningen UR. Retrieved from https://library.wur.nl/WebQuery/wurpubs/510717

Puente-Rodríguez, D., Bos, A.P., Lahr, J. & Hoeksma, P. (2019). Antimicrobiële resistentie en residuen van diergeneesmiddelen (antibiotica) in een circulaire veehouderij; Tegengaan van verspreiding via mest en milieu. Wageningen Livestock Research, Rapport 1213.

Ranjalkar, j., & Chandy, S. J. (2019, June). India's National Action Plan for antimicrobial resistance – An overview of the context, status, and way ahead. Journal of family medicine and primary care, 8(6), 1828-1834. Retrieved from https://pubmed.ncbi.nlm.nih.gov/31334140/

Reijs, J., Beldman, A., Zijlstra, J., Vrolijk, M., & Hoes, A. C. (2021). Building Farm-level Sustainability Programmes in Agribusiness: A 5 step cycle based on lessons from working with the dairy industry. Wageningen: Wageningen University & Research. Retrieved from https://library.wur.nl/WebQuery/wurpubs/582566

Resonance. (Jul 2020). Existing Projects and Social Dynamics of the Whiteleg Shrimp Industry in Andhra Pradesh, India. India: Resonance. Retrieved from https://www.resonanceglobal.com/hubfs/PAM%20India%20-%20Existing%20Projects%20&%20Social%20Dynamics.pdf?hsCtaTracking=6852b48e-a80f-4d27-8622-259793bb5cfa%7C3fa8696e-61cb-4b3f-b58e-808187d1a904

Reverter, M., Sarter, S.,Caruso, D., Avarre, J.C. and Combe, M. et al. (2020). Aquaculture at the crossroads of global warming and antimicrobial resistance

Santos, L., & Ramos, F. (2018, March). Antimicrobial resistance in aquaculture: Current knowledge and alternatives to tackle the problem. International Journal of Antimicrobial Agents, 52(2), 135-134. Retrieved from https://www.researchgate.net/publication/323850438_Antimicrobial_resistance_in_aquaculture_Current_knowledge_and_alternatives_to_tackle_the_problem

Schar, D., Klein, E. Y., Laxminarayan, R., Gilbert, M., & Van Boeckel, T. P. (2020, Dec). Global trends in antimicrobial use in aquaculture. Scientific Reports (10), 21878. Retrieved from https://www.nature.com/articles/s41598-020-78849-3#citeas

Schar, D., Zhao, C., Wang, Y. et al. Twenty-year trends in antimicrobial resistance from aquaculture and fisheries in Asia. Nat Commun 12, 5384 (2021). https://doi.org/10.1038/s41467-021-25655-8

Serrano, P. H. (2005). Responsible use of antibiotics in aquaculture. Rome, Italy: FAO. Retrieved from https://www.researchgate.net/publication/239587893_Responsible_Use_of_Antibiotics_in_Aquaculture

Shefat, S. H., & Rahman, B. S. (2018, October). Use of Probiotics in Shrimp Aquaculture in Bangladesh. ACTA SCIENTIFIC MICROBIOLOGY, 1(11), 20-27. Retrieved from https://actascientific.com/ASMI/pdf/ASMI-01-0126.pdf

Shinn, A.P. et al (2018). Asian Shrimp Production and the Economic Costs of Disease. Asian Fisheries Science 31S (2018): 29–58

Sinha, R., & Khurana, A. (2016, October). Antibiotic Use and Waste Management in Aquaculture-CSE Recommendations from a case-study in West Bengal. Centre for Science and Environment, 1-16. Retrieved from https://www.researchgate.net/publication/309727772_Policy_Brief_Antibiotic_Use_and_Waste_Management_in_Aquaculture-_CSE_Recommendations_from_a_case-study_in_West_Bengal

Stentiford, G. D., Bateman, I. J., Hinchliffe, S. J., Bass, D., Hartnell, R., Santos, E. M., Tyler, C. R. (2020, August). Sustainable aquaculture through the One Health lens. Nature Food(1), 468-474. Retrieved from https://www.nature.com/articles/s43016-020-0127-5

Stentiford, G.D., Bateman, I.J., Hinchliffe, S.J. et al. Sustainable aquaculture through the One Health lens. Nat Food (2020). https://doi.org/10.1038/s43016-020-0127-5

SustainAbility. (2020, January). 2020 PROGRESS REPORT. Geneva: AMR Industry Alliance. Retrieved from https://www.amrindustryalliance.org/wp-content/uploads/2020/01/AMR-2020-Progress-Report.pdf

Swapna K, Rajesh R, Lakshmanan P. (2012). Incidence of antibiotic residues in farmed shrimps from the southern states of India. Indian J Geo Mar Sci 2012; 41 : 344-7.

Taneja, N., & Sharma, M. (2019, February). Antimicrobial resistance in the environment: The Indian scenario. The Indian Journal of medical research, 149(2), 119-128. Retrieved from https://pubmed.ncbi.nlm.nih.gov/31219076/

The Nature Conservancy (2021). Global Principles of Restorative Aquaculture. Arlington, VA

Thornber, K., Verner-Jeffreys, D., Hinchliffe, S., Rahman, M. M., Bass, D., & Tyler, C. R. (2019, July). Evaluating antimicrobial resistance in the global shrimp industry. Reviews in Aquaculture, 12(2), 966-986. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1111/raq.12367

Umweltbundesamt. (2018). Antibiotics and Antibiotic Resistances in the Environment: Background, Challenges and Options for Action. Dessau-Roßlau, Germany: Umweltbundesamt (German Env. Agency/UBA).

UNEP (2017). Frontiers 2017 Emerging Issues of Environmental Concern. United Nations Environment Programme, Nairobi.

United Nations Food Systems Summit 2021 Scientific Group. The True Cost and True Price of Food. https://sc-fss2021.org/

Van Boeckel TP, Gandra S, Ashok A, Caudron Q, Grenfell BT, Levin SA, Laxminarayan R. Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data. Lancet Infect Dis 2014 Jul; 14: 742–750 http://dx.doi.org/10.1016/S1473-3099(14)70780-7

Watts, J. E., Schreier, H. J., Lanska, L., & Hale, M. S. (2017, June). The Rising Tide of Antimicrobial Resistance in Aquaculture: Sources, Sinks and Solutions. Marine Drugs, 15(6), 158. Retrieved from https://www.mdpi.com/1660-3397/15/6/158

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE). (2019). MONITORING AND EVALUATION OF THE GLOBAL ACTION PLAN ON ANTIMICROBIAL RESISTANCEFramework and recommended indicators. Geneva: WHO. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/325006/9789241515665-eng.pdf?ua=1

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE). (January 2017). Monitoring and Evaluation of the Global Action Plan on Antimicrobial Resistance (AMR): Regional ExpertConsultation on Monitoring and Evaluation of AMR Interventions. Expert Consultation on Monitoring and Evaluation of Antimicrobial Resistance (AMR) Interventions (p. 40). Wachington, DC: FIU. Retrieved from https://www3.paho.org/hq/index.php?option=com_content&view=article&id=13040:expert-consultation-on-monitoring-and-evaluation-of-antimicrobial-resistance-amr-interventions&Itemid=42280&lang=en

World Health Organization, Food and Agriculture Organization of the United Nations & World Organisation for Animal Health. (2019). MONITORING AND EVALUATION OF THE GLOBAL ACTION PLAN ON ANTIMICROBIAL RESISTANCE. World: World Health Organization. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/325006/9789241515665-eng.pdf?sequence=1&isAllowed=y

WWF (2020) Living Planet Report 2020 - Bending the curve of biodiversity loss. Almond, R.E.A., Grooten M. and Petersen, T. (Eds). WWF, Gland, Switzerland.

Zarei-Baygi, A., Adam L. Smith (2021). Intracellular versus extracellular antibiotic resistance genes in the environment: Prevalence, horizontal transfer, and mitigation strategies, Bioresource Technology, V.319

Zhao, Y., Yang, Q. E., Zhou, X., Wang, F.-H., Muurinen, J., Virta, M. P., . . . Zhu, Y.-G. (2020, November). Antibiotic resistome in the livestock andaquaculture industries: Status and solutions. Critical Reviews in EnvironmentalScience and Technology,. Retrieved from https://www.tandfonline.com/doi/full/10.1080/10643389.2020.1777815

World Antimicrobial Awareness Week. Antimicrobial Resistance Programme India, Webinar October 2021. https://www.cseindia.org/one-health-action-to-preserve-antibiotics-10458

FAO (2021) Technical Seminar on Aquaculture Biosecurity: Understanding Antimicrobial Resistance (AMR) in Aquaculture Webinar, 13 April 2021 - 14 April 2021

1 Understanding the source of AMR in aquaculture, Dr Iddya Karunasagar Senior Director, International Relations Nitte University, India

2 Development and implementation of national action plans to curb AMR in Chinese Aquaculture, Dr Aihua Li Principal Investigator of the State Key Laboratory of Freshwater Ecology and Biotechnology, Institute of Hydrobiology, Chinese Academy of Sciences

3 Singapore's efforts in aquaculture biosecurity and AMR, Dr Zhan Pei Heng Singapore Food Agency, Singapore

4 Laboratory determination of susceptibility to antibiotics of bacteria isolated from aquatic animals, Dr Peter Smith Scientist Department of Microbiology, School of Natural Science, National University of Ireland

5 Correct diagnostics: prerequisite for prudent and responsible antimicrobial administration, Dr Snježana Zrnčić Head, Laboratory for Diseases of Fish and Mollusks at Croatian Veterinary Institute

6 AMR and the environment: what we know and what we don't know, Dr David Verner-Jeffreys Scientist, UK Centre for Environment, Fisheries and Aquaculture Science

7 Genetic mechanisms of AMR in aquaculture pathogens, Dr Mark Lawrence Professor, Mississippi State University College of Veterinary Medicine, USA

8 OIE's work on AMR in aquatic animals – international standards, Dr Dante Matéo Chargé de Mission with focus on aquatic animals Antimicrobial Resistance and Veterinary Products Department, OIE

9 Thailand national action plan on antimicrobial use and AMR in aquaculture, Dr Thitiporn Laoprasert Scientist, Aquatic Animal Health Research Institute Thailand Department of Fisheries

10 Philippines national action plan on AMR in aquaculture, Dr Sonia Somga Chief, Fish Health Section Philippine Bureau of Fisheries and Aquatic Resources

11 The Norwegian approach to AMR in aquaculture, Dr Edgar Brun Head, Epidemiology Section Director, Department of Aquatic Animal Health and Welfare Norwegian Veterinary Institute

12 Risk of AMR development and pathogen transfer in global transport of ornamental fish, Dr Olga Haenen Head, National Reference Laboratory for Fish, Shellfish and Crustacean Diseases, Wageningen Bioveterinary Research

13 Avoiding situations that allow development of bacterial virulence and AMR in cage farming of tilapia in Africa, Dr avid Huchzermeyer Veterinary Specialist, Research Associate (Rhodes University) and Extraordinary Associate Professor (University of North West), South Africa

14 Emerging trends in AMR in aquaculture: review of governance frameworks and relevant literature, Dr Andrea Caputo Molecular Microbiologist and AMR Specialist Senior Research Scientist, EMPE Diagnostics, Sweden

15 Responsible and prudent use of antimicrobials in aquaculture: Chile experience, Dr Alicia Gallardo Undersecretary of Fisheries and Aquaculture Chile

16 Regional AMR Monitoring and Surveillance Guidelines Volume 3: Monitoring and surveillance of AMR in Bacteria from Aquaculture, Dr Mary Gordoncillo Regional Project Coordinator, Regional Office for Asia and the Pacific, FAO

17 Residues of Veterinary Drugs Detected during Import Inspection of Aquaculture Products (2016-2019), Dr Giulia Loi Consultant, Fisheries Division, FAO

18 Tripartite and FAO Action Plan on AMR 2021-2025, Dr Alejandro Dorado Garcia/Dr Jing Xu Animal Production and Health Division, FAO

APUA, Alliance for the Prudent Use of Antibiotics, www.apua.org

EAAD, European Antibiotic Awareness Day, ecdc.europa.eu/en/EAAD

EARS-Net, European Antimicrobial Resistance Surveillance Network, www.ecdc.europa.eu/en/activities/surveillance/EARS-Net

ECDC, European Centre for Disease Prevention and Control, ecdc.europa.eu/en/healthtopics/antimicrobial-resistance-and-consumption

FAO, Food and Agriculture Organisation of the United Nations, www.fao.org/antimicrobial-resistance

FAO's approach to the challenge of the use of antimicrobials in agriculture. Dr Keith Sumption, Chief Veterinary Officer, FAO. India, 20 November 2020 https://cdn.cseindia.org/attachments/0.92359600_1605875702_keith-sumption.pdf

http://documents.worldbank.org/curated/en/703711517234402168/Operational-framework-forstrengthening-human-animal-and-environmental-public-health-systems-at-their-interface

https://acrobat.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3Ab5b86397-e5e1-4ed9-bd01-637466a89347#pageNum=1

https://ahpsr.who.int/publications/i/item/global-action-plan-on-antimicrobial-resistance

https://amr.biomerieux.com/en/challenges/from-farm-to-food-to-people-one-health/

https://aquaculture2020.org/uploads/gca-tr1-aquaculture-systems.pdf

https://blog.marketresearch.com/the-growing-pharmaceuticals-market-expert-forecasts-and-analysis

https://cdn.ymaws.com/www.ser.org/resource/resmgr/publications/ser_international_standards_.pdf

https://chapter.ser.org/europe/declaration-on-eu-restoration-law/

https://civileats.com/2022/03/04/op-ed-evidence-agroecology-transform-food-system-justice-sovereignty/

https://commerce.gov.in/press-releases/india-exports-1149341-mt-of-marine-products-during-2020-21-aquaculture-sector-performs-better-uptick-in-tilapia-and-ornamental-fish-exports/

https://docs.wbcsd.org/2020/05/WBCSD_V2050IB_COVID19.pdf

https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030/eu-nature-restoration-targets_nl

https://ec.europa.eu/health/sites/default/files/antimicrobial_resistance/docs/amr_2017_action-plan.pdf

https://ec.europa.eu/health/system/files/2020-01/amr_2017_action-plan_0.pdf

https://edepot.wur.nl/138451

https://edepot.wur.nl/506640

https://enaca.org/?id=441

https://futureoffood.org

https://futureoffood.org/insights/the-politics-of-knowledge-compendium/

https://hbr.org/2019/01/rethinking-efficiency?mod=article_inline

https://hbr.org/2019/01/the-costs-of-complexity-are-hard-to-see?ab=seriesnav-spotlight

https://library.wur.nl/WebQuery/wurpubs/fulltext/407609

https://media-publications.bcg.com/BCG-A-Strategic-Approach-to-Sustainable-Shrimp-Production-Thailand-July-2019.pdf

https://mpeda.gov.in/?page_id=3447

https://mpeda.gov.in/?page_id=5130

https://ncoh.nl

https://news.mongabay.com/2021/12/conservation-and-food-production-must-work-in-tandem-new-study-says/

https://news.mongabay.com/2022/01/indonesia-aims-for-sustainable-fish-farming-with-aquaculture-villages/

https://storage.googleapis.com/wzukusers/user-29156531/documents/add7f51c75ad4b8ca0ffd87390214cd1/Chile%20Oct%202021.pdf

https://sustainablefish.org/wp-content/uploads/2021/09/Farmed-shrimp-strategy-report-Dec-2018.pdf

https://thefishsite.com/articles/antibiotics-in-aquaculture-are-they-needed

https://thefishsite.com/articles/norwegian-salmon-sector-sets-new-antibiotics-benchmark

https://www.agroberichtenbuitenland.nl/documenten/rapporten/2017/04/26/aquaculture-opportunities-and-challenges-in-andhra-pradesh-india

https://www.amr-insights.eu/category/news/healthy-animals/

https://www.blueyou.com/page/Programmes/Selva_Shrimp

https://www.brabantsemilieufederatie.nl/wp-content/uploads/sites/18/2019/02/The_Potential_of_Permaculture_Principles_in_the_Agrifood_Transition_vanBemmel_Grimm_vanderMaas_Beers.pdf

https://www.cseindia.org/amr-the-conservation-agenda--11054

https://www.ecoshape.org/en/cases/rehabilitation-of-a-mangrove-mud-coast-in-timbul-sloko-java-indonesia/abstract/

https://www.eitfood.eu/projects/the-regenerative-agriculture-revolution-2020

https://www.euractiv.com/section/health-consumers/news/over-1-million-people-died-in-2019-from-antimicrobial-resistance-study/

https://www.fao.org/3/ca5602en/ca5602en.pdf

https://www.fao.org/3/cb2601en/cb2601en.pdf

https://www.fao.org/3/cb4850en/cb4850en.pdf

https://www.fao.org/antimicrobial-resistance/key-sectors/plant-production/en/

https://www.fao.org/documents/card/en/c/ca9229en/

https://www.fao.org/fi/oldsite/ar/nems/news/detail_news.asp?lang=ar&event_id=41254

https://www.fao.org/fileadmin/user_upload/COFI/VirtualDialoguesCOFI34/13_SorgeloosDeShryverMicrobialManagementFAN61.pdf

https://www.fao.org/fishery/meetings/en

https://www.fraudstorytelling.com/movies/the-real-price-of-cheap-medicines/

https://www.globalgoals.org

https://www.globalseafood.org/advocate/how-india-became-the-worlds-top-shrimp-producer/?utm_source=Informz&utm_medium=email&utm_campaign=Informz%20email&_zs=bGg7f1&_zl=C9GK7

https://www.globalseafood.org/advocate/regenerative-ocean-farming-is-trending-but-can-it-be-a-successful-business-model/?utm_campaign=The%20Advocate&utm_content=193983339&utm_medium=social&utm_source=linkedin&hss_channel=lcp-11079975

https://www.globenewswire.com/news-release/2020/01/17/1972092/0/en/Global-Pharmaceuticals-Industry-Analysis-and-Trends-2023.html#:~:text=As%20per%20the%20research%2C%20the,growth%20pattern%2C%20and%20market%20challenges.

https://www.hatcheryfm.com/hfm-article/1715/Indonesia-to-establish-aquaculture-villages/

https://www.iucn.org/sites/dev/files/content/documents/iucn_position_paper_for_unfccc_cop26_-_final.pdf

https://www.metabolic.nl/publications/global-food-system-an-analysis-pdf/

https://www.metabolic.nl/what-we-do/systems-thinking/

https://www.montereybayaquarium.org/stories/shrimp-farming-changing-climate?utm_source=wordfly&utm_medium=email&utm_campaign=cop_26&utm_content=version_A&sourceNumber=0

https://www.nairobiconvention.org/CHM%20Documents/WIOSAP/guidelines/GuidelinesonMangroveRestorationForTheWIO.pdf

https://www.nature.com/articles/d41586-021-03044-x?utm_source=Nature+Briefing&utm_campaign=e65be953b8-briefing-wk-20211105&utm_medium=email&utm_term=0_c9dfd39373-e65be953b8-46511554

https://www.nature.com/articles/d41586-021-03044-x?utm_source=Nature+Briefing&utm_campaign=e65be953b8-briefing-wk-20211105&utm_medium=email&utm_term=0_c9dfd39373-e65be953b8-46511554

https://www.nature.com/articles/d41586-021-03044-x?utm_source=Nature+Briefing&utm_campaign=e65be953b8-briefing-wk-20211105&utm_medium=email&utm_term=0_c9dfd39373-e65be953b8-46511554

https://www.nature.org/en-us/what-we-do/our-insights/perspectives/restorative-aquaculture-for-nature-and-communities/

https://www.netherlandsworldwide.nl/documents/publications/2018/05/23/joint-statement

https://www.reactgroup.org/news-and-views/news-and-opinions/year-2017/environmental-effects-of-antibiotics-in-sewage/

https://www.reactgroup.org/news-and-views/news-and-opinions/year-2017/professor-larsson-on-indias-national-action-plan-on-amr-and-emissions-from-antibiotics-production/

https://www.reactgroup.org/news-and-views/news-and-opinions/year-2017/indias-new-national-action-plan-on-antimicrobial-resistance/

https://www.resonanceglobal.com/blog/resonance-report-identifies-opportunities-to-improve-sustainability-of-whiteleg-shrimp-production-in-india

https://www.rli.nl

https://www.ruma.org.uk/wp-content/uploads/2019/10/RUMA-TTF-update-2019-two-years-on-FULL-REPORT.pdf

https://www.sciencedirect.com/journal/journal-of-invertebrate-pathology/special-issue/10LDKC57WRM

https://www.seafoodwatch.org/our-projects/antibiotics-in-aquaculture

https://www.sustainableshrimppartnership.org

https://www.systemsinnovation.io/post/food-systems-toolkit

https://www.weforum.org/agenda/2020/05/5-reasons-why-biodiversity-matters-human-health-economies-business-wellbeing-coronavirus-covid19-animals-nature-ecosystems/

https://www.weforum.org/agenda/2020/10/shrimp-aquaculture-jobs-environment

https://www.who.int/antimicrobial-resistance/interagency-coordination-group/AMR_in_the_environment_implications_for_SDGs_SYEssack_UKZN.pdf

https://www.who.int/docs/default-source/documents/no-time-to-wait-securing-the-future-from-drug-resistant-infections-en.pdf

https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

https://www.worldfishcenter.org/blog/worldfish-champions-resilient-aquatic-food-systems-cop26

https://www.worldfishcenter.org/publication/systems-thinking-approach-identify-and-assess-feasibility-potential-interventions

OIE, The World Organisation for Animal Health, www.oie.int/en/for-the-media/amr

WHO, World Health Organization, www.who.int/drugresistance

www.aquaculture2020.org/declaration/

www.fao.org/3/ne576en/ne576en.pdf

www.fao.org/nutrition/policies-programmes/en/

www.fao.org/one-health/en/

Annexes

Program Technical Meeting dd 1-10-2021

- Intro 3 Approaches to address AMR
- Ecological Approaches, Prof. Sorgeloos
- Solidaridad India
- Antibiotic-free shrimp farming in India
- AMR Insights
- Dutch Aquaculture Experts
- CreveTec, Biofloc systems
- TipTopp Aquaculture Probiotics
- Value Chain Training Q-Point
- EU Market & Green Deal
- Food Insights

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Sustainable Aquaculture Solutions

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