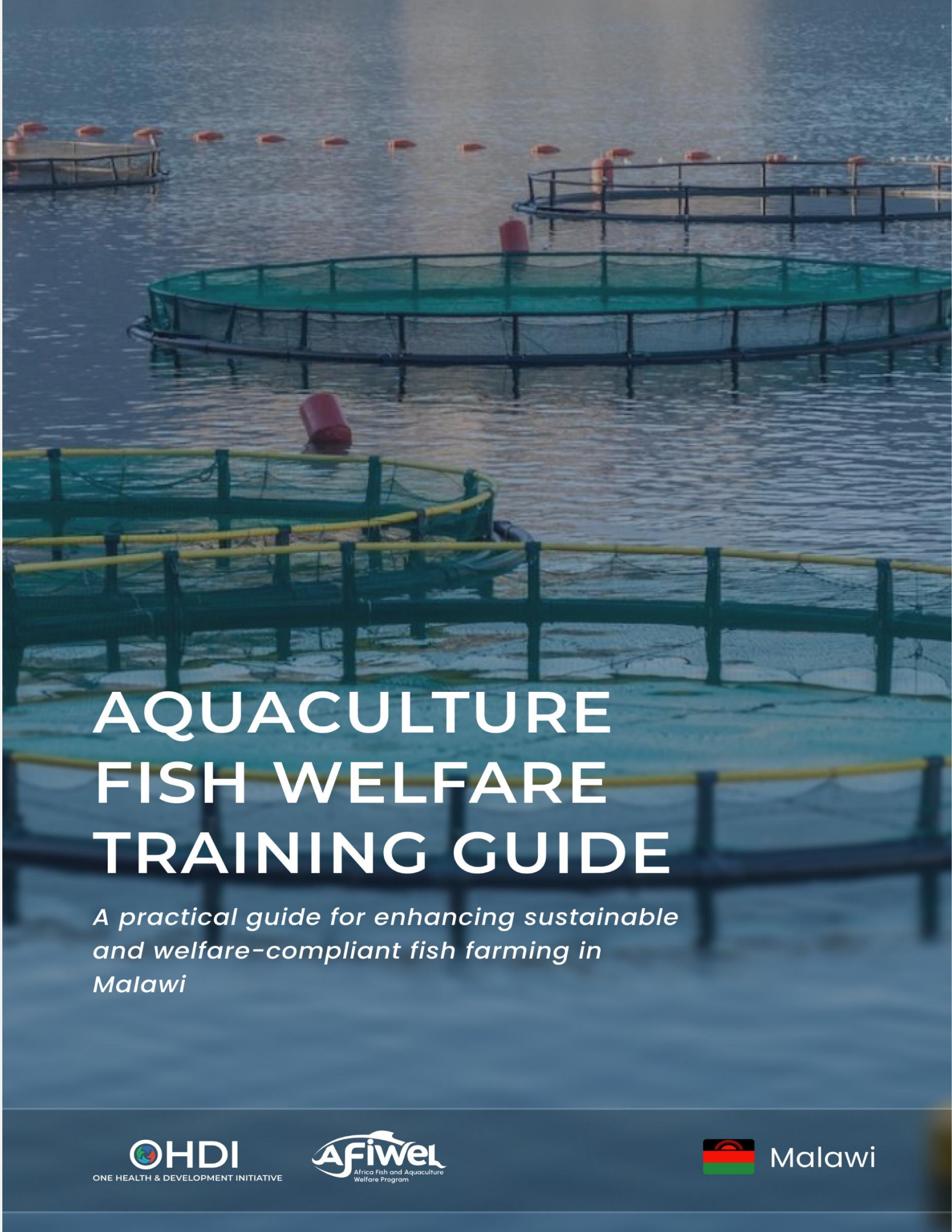

AQUACULTURE FISH WELFARE TRAINING GUIDE

A practical guide for enhancing sustainable and welfare-compliant fish farming in Malawi

OHDI
ONE HEALTH & DEVELOPMENT INITIATIVE

AFIWEL
Africa Fish and Aquaculture Welfare Program

Malawi

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ABREVIATIONS AND ACRONYMS

ALI	Aquatic Life Institute
AMR	Antimicrobial Resistance
ASPCA	American Society for the Prevention of Cruelty to Animals
AWFISHNET	African Women Fish Processors and Traders Network
CGIAR	Consultative Group on International Agricultural Research
EA	Effective Altruism
EE	Environmental Enrichment
EIA	Environmental Impact Assessment
EUS	Epizootic Ulcerative Syndrome
FAO	Food and Agriculture Organisation
FWI	Fish Welfare Initiative
HSUS	Humane Society of the United States
MEPA	Malawi Environmental Protection Authority
OHDI	One Health and Development Initiative
RSPCA	Royal Society for the Prevention of Cruelty to Animals
WOAH	World Organisation for Animal Health

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PREFACE

Fish welfare is increasingly recognised as a core component of sustainable and ethical aquaculture. Across Africa, where aquaculture plays a vital role in food security, livelihoods, and economic development, there is growing urgency to embed welfare principles into production systems, policy frameworks, and capacity-building efforts.

The Africa Fish and Aquaculture Welfare (AFIWEL) Program, implemented by One Health and Development Initiative (OHDI), was established to address this need. The AFIWEL program is a pan-African initiative that supports ethical, welfare-driven, safe, and sustainable aquatic life and production systems across Africa. One of its flagship initiatives is the AFIWEL Fellowship, which engages select fisheries and aquaculture professionals and experts in capacity-building, community-building, and field implementation programs to advance fish and aquaculture welfare practices and integrate them into existing sustainable aquaculture frameworks. Through this pan-African fellowship model, the program supports professionals across the continent in leading transformative action for fish and aquaculture welfare through education, stakeholder engagement, and policy advocacy.

This Fish Welfare Training Guide is one of several developed by AFIWEL Fellows. This particular guide has been tailored to the specific aquaculture realities of Malawi, providing practical, evidence-based knowledge and tools for fish farmers, aquaculture workers, extension officers, animal health professionals, and institutions involved in the fish production value chain.

The content draws from global best practices, scientific insights, and local expertise to ensure that welfare recommendations are both technically sound and contextually relevant. It covers key aspects such as water quality, stocking densities, feeding, handling, transportation, health management, and humane slaughter, all anchored in the principles of good welfare practices: freedom from pain, distress, discomfort, and suffering.

As you explore this guide, we invite you to reflect on the broader goal it serves, which is to promote responsible aquaculture systems that protect animal welfare, support livelihoods, and ensure long-term environmental sustainability. We hope it will be a valuable resource in your efforts to improve fish health, welfare, productivity and sustainability outcomes in Malawi and across Africa.

With best regards,
The AFIWEL Program Team
One Health and Development Initiative (OHDI)

MODULE 1– OVERVIEW OF AQUACULTURE IN MALAWI

This module introduces the concept of aquaculture and explores the various types of aquaculture systems used in Malawi, as well as the challenges affecting the sector's growth.

Introduction

Fish constitutes a cornerstone of food security and nutrition in Malawi, providing a vital source of animal protein for a substantial portion of the population (FAO, 2022). Historically, capture fisheries, predominantly from the vast Lake Malawi, have been the mainstay of fish supply. However, the escalating demand for fish, driven by a historically high population growth rate, coupled with the decline of wild fish stocks due to overfishing and habitat degradation, has necessitated the emergence of aquaculture as a crucial pillar for sustainable fish production and rural development (Government of Malawi, 2016).

What is Aquaculture?

Globally, aquaculture refers to the controlled rearing of aquatic organisms, including fish, shellfish, and crocodiles, as well as the cultivation of aquatic plants. It is regarded as a key agricultural and food-producing sector worldwide, often requiring varying levels of farm management activities, such as daily husbandry, biosecurity measures, feeding, and protection from predators, to increase yield. Fish are raised in a variety of water-holding structures, including ponds, pens, hapas, tanks, cages, and raceways. (Orobator *et al*, 2020), In Malawi, the principal form of aquaculture constitutes fish farming, which involves raising fish in enclosed systems.

Brief Overview of Aquaculture in Malawi

Fish farming in Malawi started in 1906 with the introduction of rainbow trout (*Oncorhynchus mykiss*) for angling (CASA, 2020).

Figure 1 Photography of Aquaculture Facilities at LUANAR Fish Farm in Malawi (Source: Africa Centre of Excellence in Aquaculture (ACE) AQUAFISH, 2023)

Malawi has experienced notable growth in its aquaculture sector. Annual fish production from aquaculture increased from under 1,000 metric tonnes in 2005 to over 12,200 tonnes in 2017, primarily through extensive pond culture, often integrated with agricultural activities on farmsteads (FAO, 2025). The Department of Fisheries further estimates that there were 17,012 smallholder aquaculture fish farmers in 2022 (Malawi Annual Economic Report, 2023), with women comprising about 38.5 per cent (CASA Malawi, 2020). Aquaculture has absorbed some of the growing labour force in Malawi, alleviating economic hardship, particularly for women seeking means of livelihood to support their families. It is seen as an alternative source of high-quality animal protein and livelihood, especially for

lower-income groups, in a context where fish stocks, fish habitats, and fishery biodiversity are at risk due to overfishing in Malawi's major water bodies.

Aquaculture Fish Production Systems in Malawi

Malawi's aquaculture has, for a long time, been characterised by a subsistence fish farming **sys**tem, where inputs and stocking densities are low. This system is well-suited to the resource constraints faced by many small-scale farmers in the country. The production systems are explained below.

Earthen Ponds

Earthen pond aquaculture constitutes the bedrock of Malawi's aquaculture sector, predominantly practised by small-scale farmers across the country. These ponds represent the most prevalent and accessible aquaculture system for rural communities. The construction of earthen ponds requires a careful selection of suitable sites, taking into account factors such as water availability, soil type, slope, and proximity to water sources. The excavation process involves digging and shaping the pond, with dimensions and depth varying depending on the farmer's needs, available land, and water resources.

Earthen Ponds in Extensive Production Systems

One common application of earthen ponds, particularly among smallholder farmers, is in extensive aquaculture systems. These systems are characterised by their low reliance on external inputs. Fertilisation primarily occurs naturally through the decomposition of surrounding vegetation and limited additions of manure from integrated agricultural activities. Stocking densities in these systems are generally low, typically ranging from 3 to 4 fish per square metre, with the fish primarily feeding on naturally occurring food sources like plankton and benthic

organisms. This reliance on natural productivity contributes to the low-cost nature of extensive earthen pond aquaculture.

However, earthen pond systems also present several challenges. Water quality fluctuations, particularly variations in temperature, dissolved oxygen levels, and pH, can significantly impact fish health and growth (Mwabumba and Chipungu, 2015). Furthermore, inadequate biosecurity measures can facilitate the spread of diseases, leading to potential economic losses for farmers. However, the productivity of earthen ponds is often limited by factors such as low stocking densities, reliance on natural food sources, and susceptibility to environmental fluctuations. This necessitates the development of improved management practices to enhance productivity and profitability.

Despite these challenges, earthen pond aquaculture plays a vital role in enhancing food security and livelihoods in rural Malawi. It provides a pathway for small-scale farmers to engage in fish production with minimal capital investment, contributing to diversified income sources and improved nutrition.

Earthen Ponds in Intensive Production Systems

It is important to note that earthen ponds are not limited to extensive production. Commercial aquaculture operations also utilise earthen ponds, but with significantly different management practices to achieve higher yields. In intensive systems, using earthen ponds, stocking densities are considerably higher, and the fish are primarily fed formulated commercial diets. These systems often incorporate regular fertilisation (both organic and inorganic) to boost natural productivity and may require aeration and more intensive water quality management to support the higher biomass.

Figure 2 Photography of Earthen Ponds in Nkhata-bay Captured by Meriam Msatilomo Phiri

Integrated Agriculture Aquaculture Systems (IAA)

Integrated agriculture-aquaculture (IAA) systems in Malawi offer a promising approach to sustainable and diversified livelihoods. These systems combine fish farming with other agricultural activities, such as crop production, poultry or livestock rearing, to enhance resource utilisation, reduce environmental impact and maximise profits.

Common examples of IAA in Malawi include rice-fish farming and livestock/poultry-fish farming. In rice-fish farming, fish are cultured in paddy fields, utilising the natural ecosystem to enhance productivity and reduce environmental impact. Rice provides shade and organic matter to the water, while fish contribute to nutrient cycling and help control weeds. Kilombero rice varieties do well in this integration, unlike the faya rice variety. Three (3) fish species suitable for rice-fish integration include Shire tilapia (*Oreochromis shiranus*),

Redbreast tilapia (*Coptodon rendalli*), and African catfish (*Clarias gariepinus*) (MIP 1-2024).

Figure 3 Photography of Viphya Chambo Integrated Farm, 2022: Captured by Meriam Msatilomo Phiri

Integrating Livestock and Fish Farming

Livestock-fish integration presents a synergistic approach where animal waste, particularly from goats, cattle, pigs, and poultry such as chickens and ducks, serves as a valuable organic fertiliser for fish ponds. This not only enriches the pond environment but can also contribute to improved water quality. These integrated systems offer significant advantages, including more efficient resource utilisation, a reduced environmental footprint, and enhanced livelihoods, especially for small-scale farmers. By combining diverse agricultural activities, farmers can diversify their income streams, lessen their dependence on external inputs, and boost overall farm productivity.

Evolution towards Improved Earthen Pond Aquaculture

Building upon traditional practices, fish farmers have increasingly adopted improved production systems within earthen pond aquaculture, primarily focusing on the following key areas:

- **Optimised Pond Design:** Emphasising the construction of well-engineered ponds featuring appropriate dimensions, stable sloping banks to prevent erosion, and efficient water management through adequate inlets and outlets to promote water circulation and minimise losses.
- **Enhanced Water Quality Management:** Implementing fundamental water quality monitoring and management practices. This includes regular adjustments of water levels, routine testing of critical parameters such as dissolved oxygen, pH, temperature, ammonia, and nitrite, alongside the adoption of simple aeration techniques to support optimal fish health and growth.
- **Sustainable Pond Productivity Management:** Promoting the application of organic fertilisers like compost and manure to naturally enhance pond productivity while minimising potential negative environmental impacts.
- **Robust Disease Prevention and Control:** Strengthening biosecurity protocols to prevent the introduction and spread of fish diseases. Key measures include thorough disinfection of equipment, controlled access to pond areas, the use of foot baths at entry points, and consistent monitoring of fish health.
- **Improved Access to Quality Inputs:** Facilitating access for farmers to essential, high-quality inputs such as disease-free and fast-growing fish seed, affordable and nutritionally balanced feeds, and readily available veterinary services to improve both productivity and profitability.
- **Effective Farmer Training and Extension:** Providing comprehensive training and ongoing extension services to equip farmers with the knowledge and

skills in improved aquaculture techniques, covering areas like pond construction, water quality management, feeding strategies, and disease prevention.

The adoption of these enhanced management practices holds significant potential to increase the productivity and profitability of earthen pond aquaculture in Malawi, thereby contributing to sustainable rural development and improving the livelihoods of local communities.

Figure 4 Photography of Cage Aquaculture in Lake Malawi, Source: Lake Malawi Aquaculture Limited 2024

Cage Fish Farming

Cage aquaculture in Malawi presents a promising avenue for production, offering potential for increased yields and improved livelihoods. This method involves rearing fish within net enclosures suspended in open water bodies. Compared to traditional production systems, cage culture offers several advantages, such as high stocking densities and fast growth rates, which are perceived as advantages of more intensive systems associated with cage culture. Furthermore, open-water fish cages provide improved water quality, which enhances oxygen levels and

reduces waste accumulation. By utilising open water bodies, cage culture minimises the need for land-based infrastructure. However, cage culture also presents challenges. Potential environmental impacts include nutrient enrichment, disease outbreaks, and predation. The expansion of cage production may also compete with existing capture fisheries activities, potentially impacting the livelihoods of artisanal fishers.

To ensure sustainable development, a robust regulatory framework is crucial. This framework should address environmental concerns, promote responsible aquaculture practices, and ensure the equitable distribution of benefits among stakeholders. By mitigating potential risks and promoting sustainable practices, cage aquaculture can contribute significantly to economic growth, food security, and poverty reduction in Malawi.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion

Introduce yourselves. Farmers to describe their fish farm culture system, species of fish, number of fish, location, successes, and challenges, etc.). Others (non-

farmers) should discuss why they are taking the course and what they seek to benefit.

- What is/are the most common fish farming systems practised in your area? Why is this system common?
- Tell us which fish farming system you prefer the most and why. Share your personal experiences (if any) with your preferred fish farming system, including the advantages and disadvantages.
- Have you practised integrated aquaculture before? If yes, share details of the integrated fish farm system, your experience with it, and what you consider as advantages and disadvantages of the system.
- Are you, family members or your workers trained in any biosecurity measures to be followed at a fish farm?
- What biosecurity measures are in place at your fish farms to ensure that diseases and parasites do not enter and spread on your farm

MODULE 2 – INTRODUCTION TO ANIMAL WELFARE

This module provides a basic introduction and overview of animal welfare, including the definition of animal welfare, information on general animal welfare principles and rationale, and the negative impacts of not adhering to animal welfare demands. We also introduce the five freedoms and domains of animal welfare and share insights into general animal/fish welfare violations and practices. Lastly, we provide insights into the provisional country-level legal frameworks in Malawi regarding animal welfare.

Overview, History and Trends of Animal Welfare

The World Organisation for Animal Health (OIE) Terrestrial Animal Health Code (2016)1 defines animal welfare as: "how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear and distress." Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing.

Although once a marginalised field, animal welfare has gained increasing prominence over the past three decades. This growth reflects a broader recognition of the intrinsic connection between animal sentience and overall well-being. Initially, the focus of animal welfare was primarily on physical health, disease detection, and general management practices (Pinillos *et al*., 2015). However, the field has since evolved to encompass a deeper understanding of animals' social behaviours, cognitive capacities, and their ability to perceive and express pain and suffering (Mendl *et al*., 2009; Broom, 2011).

The following provides chronological, notable highlights of events in the evolution of animal welfare:

1) **Ancient Civilisations (Prehistoric Times - 600 BCE):**

- Early human societies had varying attitudes toward animals, ranging from reverence and protection to exploitation.
- Some ancient civilisations, like the ancient Egyptians and Greeks, held certain animals in high regard and established laws to protect them.

2) Religious Influence (600 BCE - 1800 CE):

- Religious texts, such as the Old Testament in Judaism and Hindu scriptures, promoted compassion and respect for animals.
- Philosophers like Pythagoras, and later Saint Francis of Assisi, advocated for the ethical treatment of animals.

3) Animal Welfare Movement (1800s):

- The Industrial Revolution brought increased urbanisation and factory farming practices, leading to concerns about animal welfare.
- Influential figures such as Richard Martin and William Wilberforce in Britain campaigned for the welfare of working animals and passed laws against animal cruelty.

4) Formation of Animal Welfare Societies (19th Century):

- Animal welfare societies, such as the Royal Society for the Prevention of Cruelty to Animals (RSPCA), founded in 1824, emerged to promote animal welfare and enforce animal protection laws.

5) Laboratory Animal Welfare (20th Century):

- Concerns grew regarding the use of animals in scientific experiments, leading to the establishment of regulations and guidelines for laboratory animal welfare.
- Organisations like the American Society for the Prevention of Cruelty to Animals (ASPCA) and the Humane Society of the United States (HSUS) expanded their work to address animal experimentation.

6) Modern Animal Welfare Movement (Late 20th Century - Present):

- Animal welfare concerns expanded to various areas, including factory farming, animal entertainment, and wildlife conservation.
- Animal welfare legislation and regulations are being enacted globally, focusing on issues such as animal transportation, humane slaughter, and the use of animals in entertainment.
- Non-governmental organisations (NGOs) and grassroots movements are playing a significant role in advocating for animal welfare and raising awareness about animal cruelty.

However, despite these remarkable improvements in best practices globally, poor animal welfare practices are still prevalent and remain a challenge. This apparent neglect has been attributed to several reasons, such as poor awareness, inadequate resources, poor policy frameworks, and socio-cultural influences [including traditional or religious biases], among other constraints.

On a more positive note, animal welfare is also receiving increasing recognition as an important contribution to an interconnected myriad of animal, human, environmental and ecosystem health (One Health), and sustainable development outcomes. This has led to the development of the ongoing 'One Welfare' concept, which encourages interdisciplinary partnerships to improve animal and human welfare simultaneously, incorporating the environmental components of welfare (Marchant-Forde and Boyle, 2020).

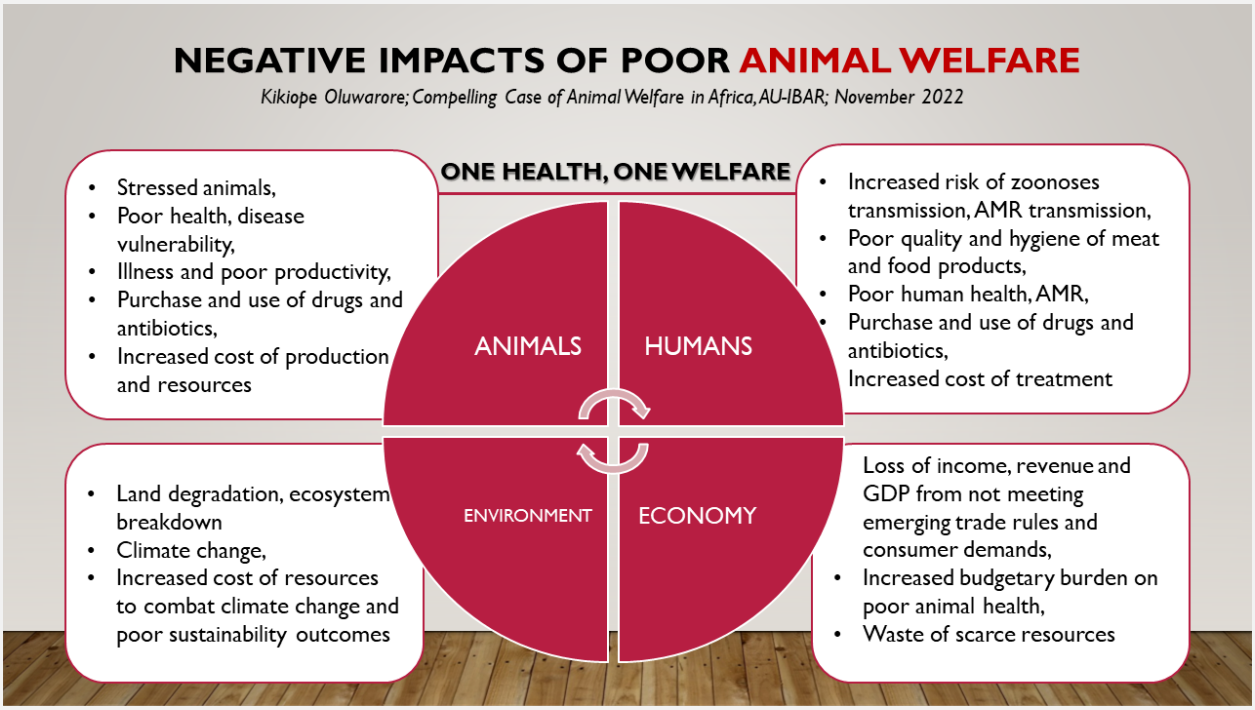

Figure 5 Diagram of Compelling Case of Animal Welfare in Africa, AU-IBAR, Africa Conference for Animal Welfare, November 2022 (Oluwarore 2022)

Improved animal welfare practices can contribute to a reduction in animal diseases and zoonoses in humans (Madzingira 2017), reduces mortality, improves growth, increases feed efficiency and, all in all, improves production performance; foster human and animal bonds that improve human health and social wellbeing (Freisinger, 2021); and positively impact food safety and meat quality (Animal Welfare Institute, 2018). Furthermore, according to CIWF (2020), addressing welfare concerns such as housing and good management practices has positive impacts on animal health, farms' environmental footprint, and economic and social performance. This recognition has stimulated concerted efforts by stakeholders at all levels to improve the welfare of animals, reduce their pain and suffering, and enhance their health and well-being.

The Five Freedoms of Animal Welfare

In the quest for improved animal welfare, a major advancement is the development of the "Five Freedoms of Animal Welfare". This has contributed to

the recognition, understanding and establishment of good animal welfare systems and practices. The Five Freedoms of Animals are globally validated basic guidelines and indicators used to determine the welfare status of animals, including fish. It has been touted by several in-country and international animal health and welfare organisations, including the World Organisation for Animal Health (WOAH). The 'Five Freedoms' include: freedom from thirst and hunger, freedom to display natural, normal behaviour, freedom from discomfort, freedom from fright and despair, as well as freedom from disease, pain, and injury (Mellor, 2016).

The following provides a detailed explanation of the Five Freedoms (which apply to fish):

1. **Freedom from hunger and thirst** – This implies the expected provision of adequate measures of food and water provided in timely, consistent, balanced, and nutritious rations, devoid of contaminants and free of disease-causing organisms.
2. **Freedom from discomfort** – This implies the provision of a comfortable environment that involves a healthy and good quality water ecosystem, and existence that is devoid of restrictions, unpleasant perceptions, and harsh environmental conditions (including but not limited to rainy, extreme cold or hot weather or water environment, noise, or fearful situations).
3. **Freedom from pain, injury, and disease** – This implies providing adequate care and environmental conditions that are devoid of (but not limited to) any form of infliction of painful or injurious experience, provision of standard fish management practice and biosecurity measures, prompt and quality veterinary care and treatment, and good antimicrobial stewardship.
4. **Freedom to express normal and natural behavior** – This includes the provision of conditions that are not unduly restrictive in which the fish can move around (including swimming and other fish locomotion, vocalising, feeding, and

interacting with other fishes) within the considerable limits of a protected and safe environment, duplicating its natural settings or environment as much as possible, and allowing the animals to express its natural instincts and behaviors.

5. **Freedom from fear and distress** – This includes considerate humane treatment of fish in a manner that does not induce fear, anxiety, distress, or other forms of psychological suffering to the animals.

It is essential to recognise that while all freedoms have their distinct roles, they logically interconnect and impact one another in various ways. For example, an animal's "freedom from hunger and thirst" contributes to the satisfaction of the other four freedoms.

The Five Domains of Animal Welfare

Although the Five Freedoms of Animal Welfare provide a strong basis for assessing animal welfare standards, a more updated framework called the Five Domains of Animal Welfare has since been established. The five domains include Nutrition, Environment, Health, Behaviour, and Mental Domains. These domains are described as a science-based best practice framework for assessing animal welfare and quality of life. The first four domains provide information about the animal's various experiences, which make up the fifth domain, the Mental Domain. This domain allows a distinction to be made between the physical and functional factors that affect an animal's welfare and the overall mental state of the animal, arising from these factors. It also recognises that animals can experience feelings, ranging from negative to positive. Over the last 20 years, this framework has been widely adopted by organisations globally as a tool for assessing the welfare impacts of farm animals, research procedures on animals, pest control methods, and other interventions in animal lives in many organisations.

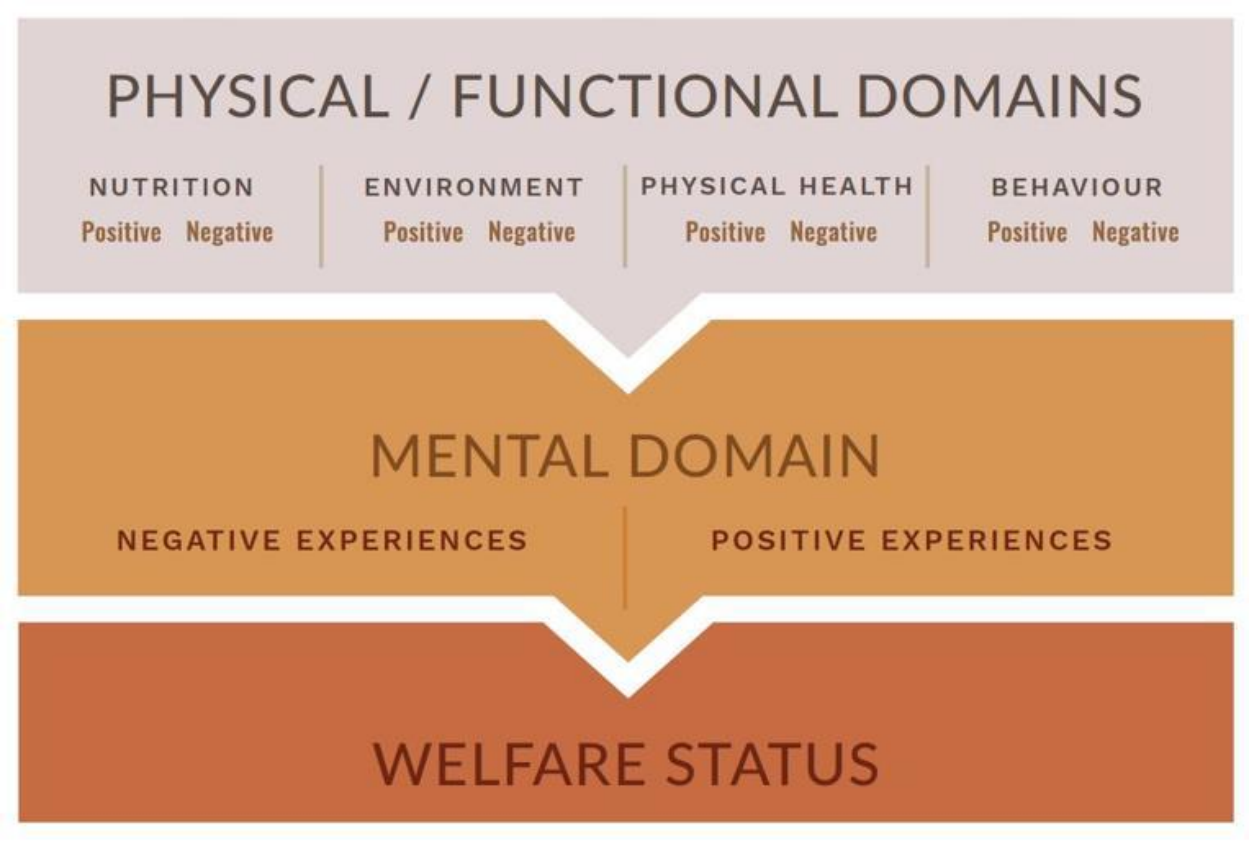

Figure 6 The Five Domains of Welfare (Source - Zoo Aquarium, Australia)

The **Royal Society for the Prevention of Cruelty to Animals (RSPCA)** shares more details on the value of the Five Domains, explaining that to help ensure animals have a 'good life', they must have the opportunity to experience positive emotions, including satisfaction and satiation. To enable this, those responsible for the care of animals need to provide them with environments that not only allow but also encourage animals to express behaviours that are rewarding. Thus, the Five Domains provide a means of evaluating the welfare of an individual or group of animals in a particular situation, with a strong focus on mental well-being and positive experiences.

Comparing and Integrating the Five Freedoms and Domains

The Five Freedoms and Five Domains frameworks comparatively contain essentially the same five elements. However, the Five Domains explore the mental state of an

animal in more detail and acknowledge that for every physical aspect that is affected, there may be an accompanying emotion or subjective experience that may also affect welfare. This is useful in terms of reinforcing the message that emotional needs are equally important as physical needs for animals. For example, Zoo Aquarium indicates that while they recognise the value of using the Five Freedoms for driving the prevention of negative welfare in animals, they also apply the Five Domains for animal welfare assessment to progress beyond preventing bad animal welfare, to include actively promoting positive animal welfare.

Table 1 Comparison between Five Freedoms and Five Domains (Source - RSPCA)

Five Freedoms	Five Domains
From hunger and thirst	Nutrition
From discomfort	Environment
From pain, injury and disease	Health
To express normal behaviour	Behavioural interactions
From fear and distress	Mental state/experiences

Key Animal and Fish Welfare Violations

In many countries, it is seen that several violations of the Five Freedoms of Animals occur to varying degrees. Although it may seem like the norm in many places (for example, in Nigeria), animal abuse is getting less accepted across the world, and animal welfare is highly regulated in many countries. Poor welfare practices common in fish and other animals are listed as follows:

- Inhumane transportation causes discomfort, such as overcrowding, exposure to uncomfortable weather, or other environmental factors, and diminished water quality.
- Inhumane slaughter (painful, fearful, or distressing to animals) and inappropriate stunning and slaughter methods.
- Inhumane handling and mutilation practices, especially without anaesthesia (such as eye-stalk ablation in female shrimp or the incision on the abdomen of the male to extract milt for artificial reproduction).
- Inhumane animal training for sports, entertainment, and catch-and-release of fish during angling for leisure.
- Factory farming, including restrictive or confined housing.
- Lack of quality and timely intervention of veterinary care and treatment (including the use of untrained animal health practitioners).
- Antimicrobial misuse (from self-medication, poor quality veterinary services or unethical practice) or overuse (to compensate for poor animal welfare-induced immunosuppression), leading to antimicrobial resistance.
- Administration of growth hormones, with resultant anatomical and physiological conditions that cause discomfort, pain, and poor health to the animal.
- Insufficient water flow or circulation, resulting in water stagnation that can lead to fish stress.
- Overflow of water inlets that can lead to oversaturation, thus causing gill damage to the fish.
- Inadequate provision of food/water, excessive fasting periods or withdrawal of food and water for manipulative purposes.
- Prolonged periods of feed restriction for fish grading, transport, slaughter, and other farm management practices such as vaccination, which can cause stress, suffering and injuries such as dorsal fin damage.

- Exposing fish to harmful or strenuous conditions during research without proper ethical and welfare considerations.
- Failure to diagnose and treat the fish for any diseases and parasites in time.
- Inadequate biosecurity measures.
- Mouth clipping to reduce aggression during breeding.
- Administration of stimulant hormones/chemicals for breeding.
- Egg and milt stripping for artificial breeding

Legal Frameworks for Animal and Fish Welfare in Malawi

In Malawi, the legal framework for animal and fish welfare is developed from a collection of existing Acts, rather than a single, overarching law. The Protection of Animals Act (Cap 66:01) serves as the primary legislation against animal cruelty, though it requires modernisation to meet contemporary welfare standards. Alongside this, the Fisheries Conservation and Management Act, 1997, plays a vital role in regulating sustainable fishing and aquaculture, indirectly supporting fish welfare.

Furthermore, the National Parks and Wildlife Act (2017) protects Malawi's wildlife, and the Control and Diseases of Animals Act (Cap 66:02) focuses on disease control, both contributing to animal well-being. A significant and positive development is the current drafting of a new fisheries strategy, which will explicitly address fish welfare. This demonstrates a growing commitment to ethical practices within Malawi's expanding aquaculture sector. The Malawi Animal Welfare Guidelines (2019), although primarily focused on terrestrial animals, do provide fundamental principles of animal welfare in general.

Despite these legislative efforts, Malawi continues to face several challenges. Domesticating or adapting existing legal frameworks to reflect current scientific understanding and ethical standards is paramount. Equally important is the effective enforcement of these legal frameworks, which requires adequate

resources and capacity. Public awareness campaigns are also essential in promoting responsible animal care. Another notable challenge is the sector-wise approach to applying these legal frameworks, rather than a collaborative effort using the One Welfare approach.

The ongoing development of the fisheries strategy presents a crucial opportunity to incorporate best practices and World Organisation for Animal Health (WOAH) guidelines into national regulations. This will help strengthen Malawi's approach to fish welfare, ensuring a more ethical and sustainable future for its aquaculture and fisheries industries. By prioritising these efforts, Malawi can improve the welfare of animals and fish, contributing to both ethical standards and sustainable economic growth. In addition, the development of the National Aquaculture Development Plan (NADP), National Aquaculture Strategic Plan 2, Fish hatchery Biosecurity Guidelines for fish hatcheries in Malawi, Fish feed technical specifications and guidelines for Malawi and Guidelines for cage fish farming on Lake Malawi, are some of the strategies that have aspects to incorporate and implement the welfare of farmed fish.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org
- Share your questions on the Discussion Forum on the online training platform

for Fish Welfare

Discussions

- Reflect on the topic of animal welfare generally. Were you aware of the concept of "animal welfare" before now? Did you consider it important in the management of animals? Have you ever thought about animal welfare in your daily activities? How do you think animal welfare can achieve better production outcomes or better food quality? Can you provide an example of how implementing animal welfare practices also improved human well-being and environmental health?
- Discuss general animal welfare practices and violations in Malawi. Which of the animal welfare violations listed are common in Malawi?
- What can be done to address and prevent poor animal welfare practices in Malawi?
- Discuss your thoughts and feedback on the animal welfare legal framework in Malawi. Are there gaps? Recommendations?
- What can be done to push for the establishment and implementation of the Animal Welfare Law (including fish welfare) in Malawi? How can you support this?

MODULE 3 – INTRODUCTION TO FISH WELFARE

This module provides an overview of farmed fish welfare, the Five Pillars of Welfare in aquaculture, and the corresponding benefits of fish welfare practices.

What Is Fish Welfare?

Fish welfare in Malawi, particularly within aquaculture, aligns with the broader definition of animal welfare, emphasising the well-being of individual fish. This includes ensuring good health, proper nutrition, and the ability to engage in natural behaviours, such as swimming, foraging, and social interactions. A state of good fish welfare encompasses: (1) optimal physical health with all biological systems functioning appropriately; (2) the ability to lead a natural life and meet behavioral needs within the environment; (3) freedom from negative experiences like pain, fear, hunger, thirst, and distress; (4) access to positive experiences such as social companionship and a conducive environment; and (5) the capacity to adapt to its environment. Challenges in Malawi's aquaculture sector, such as poor water quality, inadequate nutrition, and disease outbreaks, hinder the achievement of these welfare goals. Addressing these challenges through good aquaculture practices, improved feed quality, strengthened disease control, and enhanced access to resources is crucial for ensuring the well-being of farmed fish and the sustainable development of the aquaculture sector in Malawi.

The Five Pillars of Fish Welfare in Aquaculture

The Aquatic Life Institute has established a framework for assessing fish welfare, outlining five key pillars:

- **Environmental Enrichment**, providing a stimulating environment with suitable habitats, hiding places, and opportunities for natural behaviours;

- **Feed Composition and Feeding Practices**, ensuring a nutritionally balanced diet with appropriate nutrients and minimising the use of harmful additives;
- **Space Requirements and Stocking Density**, allowing sufficient space for fish to move freely and minimise stress;
- **Water Quality**, maintaining optimal water parameters such as temperature, dissolved oxygen, and pH levels; and
- **Stunning and Slaughter**, implementing humane handling and slaughter practices, including the use of effective stunning techniques to minimise pain and suffering. This framework provides a valuable guide for improving fish welfare in aquaculture and other aquatic animal industries.

Figure 7 The Five Pillars of Fish Welfare [Source - Aquatic Life Institute (ALI)]

Benefits of Improved Aquaculture Fish Welfare

1. Improved Fish Health and Productivity

- ***Enhanced Immune Systems:*** Healthy fish that live in optimal conditions with minimal stress develop stronger immune systems. This natural resistance to

disease significantly reduces the need for antibiotics and other medications, thereby minimising the risk of disease outbreaks.

- ***Reduced Antibiotic Resistance:*** The overuse of antibiotics in aquaculture can contribute to the development of antibiotic-resistant bacteria. By minimising the need for antibiotics through improved fish welfare practices, we can mitigate the risk of antibiotic resistance, which is a growing global health concern. This not only protects the health of farmed fish but also safeguards human health and the environment.

2. Improved Growth Rates

- ***Optimised Physiological Function:*** When fish are not stressed by poor water quality, inadequate space, or inappropriate feeding, their physiological functions, such as growth and metabolism, operate more efficiently. This translates to faster growth rates and higher yields.
- ***Increased Profitability for Farmers:*** Faster-growing fish require less time and resources to reach market size, resulting in significant cost savings for farmers. Increased yields also directly translate to higher profits, improving the economic viability of aquaculture operations.
- ***Enhanced Food Security:*** Faster growth rates contribute to increased fish production, which is crucial for addressing the growing global demand for protein and ensuring food security for a growing population.

3. Enhanced Feed Conversion

- ***Improved Nutrient Utilisation:*** Healthy fish utilise feed more efficiently, meaning a greater proportion of the feed is converted into fish biomass. This reduces feed wastage and minimises the environmental impact of feed production.

- ***Reduced Environmental Impact:*** Efficient feed utilisation minimises the amount of feed required to produce a given amount of fish. This translates to reduced pressure on wild fish populations, which are often used to produce fishmeal and fish oil for aquaculture feeds.
- ***Sustainable Aquaculture:*** Efficient feed conversion is a cornerstone of sustainable aquaculture. By minimising feed waste and optimising feed utilisation, aquaculture can contribute to a more sustainable and environmentally responsible food production system.

4. Improved Product Quality

- ***Superior Meat Quality:*** Fish raised in high-welfare conditions tend to exhibit better flesh quality, resulting in a more desirable product for consumers.
- ***Reduced Stress:*** Stress results in the production of stress hormones that negatively impact the flavour and texture of fish meat. Minimising stress leads to a higher-quality product with improved sensory attributes.

5. Environmental Sustainability

- ***Reduced Pollution:*** Improved water quality management and reduced disease outbreaks minimise the environmental impact of aquaculture operations by reducing nutrient and chemical runoff into surrounding ecosystems.
- ***Reduced Antibiotic Use:*** Lower disease prevalence reduces the need for antibiotics, protecting aquatic ecosystems and human health from the potential risks of antibiotic resistance.
- ***Efficient Resource Utilisation:*** Efficient feed utilisation and reduced mortality rates contribute to more sustainable aquaculture practices, minimising the environmental impact of feed production and reducing waste.

6. Economic Benefits

- ***Increased Profitability:*** Higher yields, reduced mortality rates, savings from purchasing of medications and improved product quality translate into increased profits for aquaculture farmers.
- ***Improved Market Access:*** Consumers are increasingly concerned about animal welfare and sustainability. High-welfare aquaculture products can command premium prices in the market, providing a competitive advantage for producers.
- ***Enhanced Livelihoods:*** Improved aquaculture practices can contribute to the economic development of rural communities, particularly in developing countries, by providing sustainable livelihoods for fish farmers.

7. Social and Ethical Considerations

- ***Improved Public Perception:*** Consumers are increasingly demanding ethically produced food. High-welfare aquaculture practices enhance the industry's ethical image, building consumer trust and confidence.
- ***Ethical Considerations:*** Prioritising fish welfare aligns with ethical considerations and promotes responsible and humane aquaculture practices, fostering a more ethical and sustainable food system.

8. Contribution to Sustainable Development

Fish welfare is intrinsically linked to sustainable development and contributes to the achievement of the United Nations Sustainable Development Goals (SDGs). As outlined in the 2023 report from the Aquatic Life Institute on the Benefits of Aquatic Animal Welfare for Sustainable Development Goals, and further emphasised by the United Nations Development Programme (UNDP, 2023), the SDGs recognise the interconnectedness of social, economic, and environmental dimensions.

- **Goal 1 - No Poverty:** Aquaculture plays a vital role in poverty reduction in Malawi, providing livelihoods for numerous small-scale farmers and contributing to local economies. Improving fish welfare enhances fish health and productivity, leading to increased incomes and improved livelihoods for fish farmers.
- **Goal 2 - Zero Hunger:** Fish is a crucial source of protein for many Malawians. By promoting sustainable aquaculture practices that prioritise fish welfare, we can ensure a reliable and nutritious food source for the growing population.
- **Goal 3 - Good Health and Well-Being:** High-welfare aquaculture practices minimise the risk of disease outbreaks, reducing the need for antibiotics and other medications. This not only protects the health of farmed fish but also minimises the risk of antibiotic resistance, safeguarding human health.
- **Goal 6 - Clean Water and Sanitation:** Improved fish welfare practices, such as optimised feeding strategies and reduced disease outbreaks, minimise the environmental impact of aquaculture by reducing nutrient and chemical runoff into surrounding water bodies.
- **Goal 12 - Responsible Consumption and Production:** Sustainable aquaculture practices, prioritising fish welfare, promoting responsible resource use, minimising waste generation, and enhancing the environmental sustainability of the sector.
- **Goal 14 - Life Below Water:** By minimising environmental impacts and reducing the risk of disease outbreaks, sustainable aquaculture practices contribute to the conservation of aquatic ecosystems.
- **Goal 17 - Partnerships for the Goals:** Achieving these SDGs requires collaboration among various stakeholders, including farmers, researchers, government agencies, NGOs, and communities. Promoting fish welfare necessitates a multi-stakeholder approach to develop and implement best

practices, share knowledge, and advocate for sustainable aquaculture development in Malawi.

9. The Right Thing for Fish

Aquaculture is a rapidly growing sector globally, and it plays an increasingly important role in food security in Malawi. However, many farmed fish experience significant welfare challenges, including disease, overcrowding, poor water quality, inadequate fish handling techniques during harvesting and slaughter, and limited opportunities to express their natural behaviours. These stressors can lead to chronic stress, impaired growth, and increased mortality rates.

Recognising fish as sentient beings capable of experiencing pain and suffering is crucial (Brown, 2014; Braithwaite, 2010; Riberolles, 2020; Babb, 2020). Just as we strive to ensure the welfare of terrestrial farm animals, we have a moral obligation to provide a good quality of life for farmed fish. This includes minimising stress, preventing disease, and providing appropriate living conditions.

Introduction to Fish Welfare Practices

In Malawi, aquaculture utilises various facilities for fish production, including earthen ponds, tanks, and cage systems. Diverse farming systems, such as extensive and intensive production methods, are implemented within these facilities. While these approaches offer significant opportunities for fish production, each presents distinct challenges that must be addressed to ensure optimal fish welfare.

Unlike their natural environment, farmed fish are confined within defined spaces, often with limitations on their natural behaviours. This necessitates careful consideration of their specific needs and the implementation of appropriate management practices to ensure their well-being. There are various fish species commonly cultured in Malawi, including African catfish (*Clarias gariepinus*) and

Tilapia species, such as *Oreochromis karongae, Oreochromis shiranus, Oreochromis mossambicus, and Coptodon rendalli.*

Key welfare considerations for fish in aquaculture settings include: meeting species-specific needs, providing environmental enrichment, maintaining optimal water quality, managing stocking density, ensuring proper nutrition, implementing disease prevention and control measures, and minimising stress during handling, transport, and slaughter. These aspects will be discussed in detail in subsequent modules.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- What new knowledge have you gained from this lecture on fish welfare?
- Drawing experience from your own fish farm (or working with fish farmers), discuss how you plan to adapt and utilise your knowledge of the "Five Pillars of Animal Welfare in Aquaculture."
- Among all the benefits listed, what are the top three benefits that you look forward to getting when you implement fish welfare? Why

MODULE 4 – GROWING SYSTEMS AND FISH WELFARE

This module equips learners with the knowledge necessary to establish successful and ethical aquaculture operations. It covers site selection, evaluates various growing systems considering fish welfare, and emphasises the crucial role of appropriate stocking densities for optimal fish health and well-being.

Establishing a successful fish farm requires careful planning and consideration of factors that significantly affect fish health and productivity, ultimately impacting investment returns. A solid foundation for any fish farming venture involves developing strategic plans, operational protocols, and well-defined procedures. These may include a comprehensive business plan, an emergency response plan, a robust biosecurity plan, environmental and social management plans (Including Environmental and social safeguards), and a clearly outlined stocking density protocol. Additionally, a skilled workforce is vital, with well-defined roles and responsibilities for staff, including farm managers and veterinarians.

Careful selection and evaluation of the growing environment are paramount for a successful fish farm in Malawi, encompassing a detailed assessment of the site's suitability, the chosen rearing system's appropriateness for the species and context, and the determination of an optimal stocking density to directly support fish health, welfare, and overall farm productivity.

Site Selection

Successful fish farming in Malawi begins with careful site selection. The chosen location significantly impacts fish health, productivity, and the overall success of the venture.

Water Source: A reliable year-round water source is crucial. While a continuous water supply is not necessary, sufficient water must be available for initial filling and regular replenishment to compensate for evaporation and seepage. Springs, streams, and groundwater are potential sources, but their quality must be assessed. Avoid using water contaminated by agricultural runoff, industrial waste, or chemicals like chlorine. Rainwater harvesting can be utilised, but careful planning is essential to address potential dry seasons.

Soil Characteristics: Soil characteristics are fundamental for successful pond construction in Malawi. Clay-rich soils are highly preferred due to their excellent water retention capabilities, which minimise seepage. In contrast, sandy soils are generally unsuitable for pond construction because their high porosity leads to significant water loss. A practical, on-site assessment of soil suitability involves squeezing a handful of moist soil into a ball and gently tossing it; if the soil ball retains its shape upon landing, it likely has a sufficient clay content for pond construction.

Environmental Considerations

- Avoid locations near industrial areas, commercial fish farms, or areas prone to flooding.
- To minimize potential negative environmental impacts of the aquaculture operation in Malawi, it is essential to conduct an Environmental Impact Assessment (EIA) or, at a minimum, submit a Project Brief to the Malawi Environmental Protection Authority (MEPA) for screening, as mandated by the Environmental Management Act (2017) and relevant guidelines, particularly for projects exceeding specified production capacities or posing risks to sensitive areas.
- Implement safeguards against extreme weather events, such as heavy rainfall and prolonged droughts, which can significantly impact fish health and survival.
- Consider noise pollution, which can stress fish and negatively impact breeding.

Other Important Factors

- ***Accessibility:*** Ensure easy access to the farm for transportation of inputs and outputs.
- ***Availability of veterinary care:*** Ensure access to qualified veterinarians and veterinary services.
- ***Community acceptance:*** Obtain community support and address any potential concerns regarding the fish farm.

Rearing Systems

In Malawi, fish rearing systems, crucial for aquaculture production, encompass various designs tailored for specific purposes like hatcheries, nurseries, grow-out operations, broodstock maintenance, and holding/transfer. These systems range from traditional earthen ponds, which are used by 99.5 per cent of small-scale farmers, to more modern approaches (Munthali et al., 2022). Cage culture, particularly in Lake Malawi, is an emerging practice, often used for tilapia farming. Lined ponds are also gaining traction, offering improved water management compared to traditional earthen ponds.

Regardless of the chosen system, prioritising fish welfare is paramount, and considerations include:

- Robust biosecurity protocols to prevent the introduction of diseases and their spread, including disinfection points and controlled access to fish rearing facilities, are critical for minimising disease outbreaks.
- To mimic the natural environment as closely as possible to allow fish to express natural behaviours. This includes environmental enrichment, such as providing structures or substrates that offer shelter and stimulate exploration, though research specific to enrichment for commonly farmed Malawian species, like tilapia, is limited and warrants further investigation.

- The physical design of the system should prevent injuries, with smooth surfaces and appropriate materials.
- Efficient waste removal is crucial for maintaining water quality, minimising stress, and preventing disease, though specific best practices for waste management in Malawian aquaculture contexts may require further development.
- Protecting fish from predators and preventing fish escapes are essential considerations. Predation can be a significant problem in earthen ponds, necessitating measures such as netting or fencing. Escapees, particularly from cage fish farming, can impact local ecosystems, potentially competing with native species or introducing disease.
- Noise and external disturbances, including those from pumps and machinery, should be minimised, as these can cause stress and negatively affect breeding.
- Cage fish farming, due to its placement in open water bodies, presents unique challenges regarding water quality management as the fish are exposed to fluctuating environmental conditions and potential pollution.
- Appropriate illumination, particularly in indoor systems, is important for fish behaviour and growth.
- Emergency plans for adverse weather events, fires, and floods are also essential for mitigating potential losses and fish suffering.
- Regular training for farm staff on best management practices and protocols is crucial for ensuring consistent and effective implementation of welfare standards.

Common Culturing Facilities and Welfare Considerations

Some common fish rearing facilities and their welfare considerations and issues are discussed in detail below.

Earthen Ponds

In Malawi, earthen ponds are a widely used aquaculture system. However, their effective management requires careful consideration of several welfare aspects, protocols, and activities to be undertaken:

- Proper soil and water analysis must be carried out to determine the suitability of the location, vegetation, and topography.
- For optimal pond siting in Malawi, prioritise locations with clay or loam-based soil (over 65% clay) and a pH between 6.5 and 8.5, avoiding sandy soils prone to water loss and wastewater infiltration, as well as areas with heavy metal deposits. A crucial consideration, especially where suitable soil is limited or in dam construction, is the use of impermeable liners like plastic to minimise water seepage and maintain water quality.
- The pond must be structured in such a way that it will not cause flooding or obstruct water drainage flow patterns in flood plains or wetlands, or cause erosion.
- Low-lying ponds should be screened with appropriate non-toxic material to prevent fish loss during flooding, as well as entry of wild fish and other predators, which may introduce diseases and also cause pain and suffering from some predators' biting wounds.
- There must be an adequate and continuous supply of good-quality water, especially in areas prone to drought.
- Water sources must be free from pollutants, as this affects fish gills and oxygen intake, causing stress, poor reproductive ability, and stunting.
- Measures to cope with predators (snakes, rodents, and birds) should be in place, and this may include the use of screens, scare-crows, and keeping the environment clean.

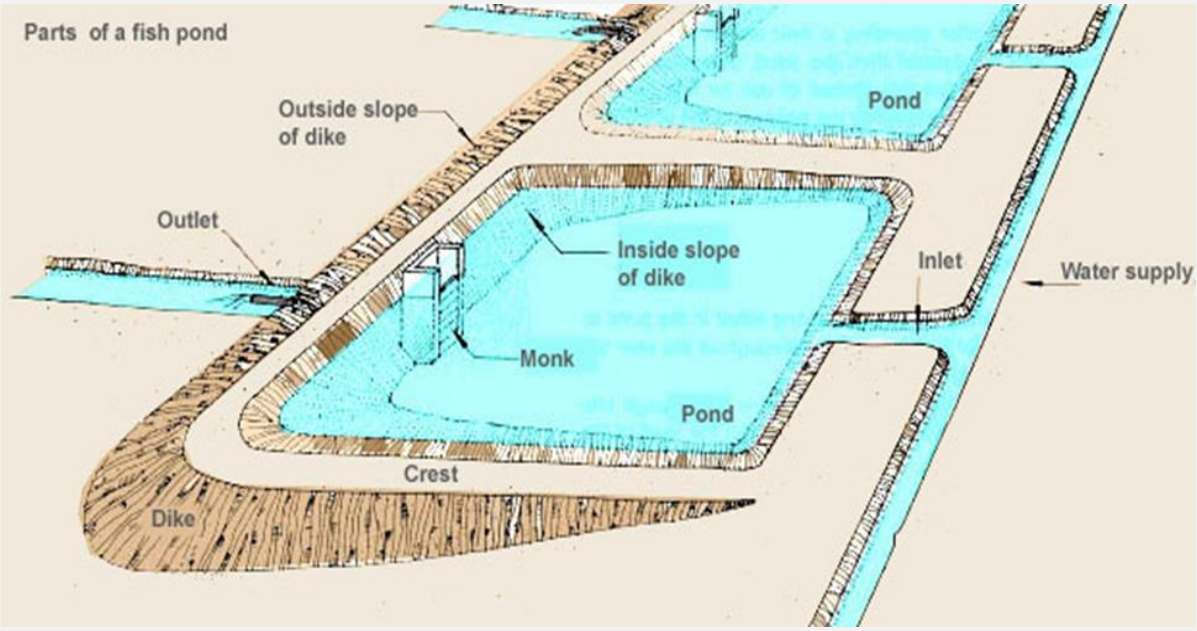

Figure 8 Photography of Schematic representation of Earthen Ponds (Source – FAO)

Common Welfare Issues with Fish Grown in Earthen Ponds

- Sorting the fish along the growing cycle will be difficult. The common practices of sorting and cropping fish often result in them being taken out of water for a considerable length of time, which can cause stress. While some fish can stay out of water longer than others (e.g. catfish, compared to tilapia), some degree of stress is still inevitable, and the practice should not be encouraged. Use of fish sorting devices, such as fish graders, should be encouraged.
- Rough handling, like throwing fish into ponds, severely compromises fish welfare by causing stress, disorientation, and potential injury; gentle handling with appropriate equipment is essential for minimising harm.
- Cannibalism and predation are often common within the earthen pond environment, especially in polyculture. Generally, growing carnivorous fish with other fish species with the intent of using these others to feed and grow the former is a grave and unapproved rearing method.

- Earthen ponds are highly vulnerable to environmental pollution and other hazards. There is a high probability of lower sanitation, which increases the risk of disease transmission from humans to the fish and vice versa.
- Some farmers try to manipulate soil quality and provide enrichment in ponds through liming and manuring using organic and inorganic fertilisers. However, caution must be exercised to prevent wrong application and overdosing. This will negatively impact water quality (growing environment) and fish welfare. There have been reported cases of fish skin bleaching and mass mortality in growing ponds during soil enrichment, as well as the accidental introduction of pathogens through the application of organic fertilisers. Such pollutants also have One Health implications that may impact both aquatic and land animals, including humans.

Concrete Tanks

Concrete ponds are often made from concrete blocks or reinforced slabs. A mixture of sand, cement and gravel is used to prevent cracks and leakages. Therefore, water flows in and out of the pond through drains. The water may be treated for use in crop farming and vegetable production or may be released into natural water bodies. Concrete tanks must be well designed with a complete drainage and overflow system. Additionally, the tank must be cured (treated with salt) before use to prevent water pollution from chemicals in the cement, as this can lower the pH and make the water acidic. They can vary in size and shape. Ideally, the tanks should be large and deep enough to reduce the rapid fluctuation of water quality, i.e. temperature and DO. The tanks should be stocked with recommended fish densities to mitigate stress among fish. The shape could be rectangular, square, circular, and is determined by several factors, such as expected production, the length of the production period, the sanitation regime, and the fish's behavioural swimming pattern. The edges of rectangular or square tanks should be rounded to allow fish to swim freely around them. Sharp edges

may lead to fish piling up around the edge, causing traumatic skin abrasions from each other's fins and increasing the risk of pathogen entry, which can lead to pain, discomfort, and sometimes diseases.

Figure 9 Concrete Tanks Constructed to House Fish; Source – Business Compiler

Common Welfare Issues with Fish Grown in Mobile Fish Pond

Increased risk of algae excess buildup on the rearing system's walls, which may affect water quality.

- Possibility of an accidental introduction of food items and waste, which will cause pollution and reduce water quality.
- High risk of water temperature fluctuations that may stress fish.

Cages and Pens

A cage is a net enclosure usually suspended in a water body, anchored on the natural waterbed, kept buoyant by floats, and used for farmed fish. A pen is a shallow water enclosure for the rearing of fish in an open water body, and often hangs near the floor of the water body. These should be constructed to avoid obstructing navigation on water, as the regular movement of the cages and pens

to allow passage to other users of the water bodies will cause extreme stress to the fish, which may affect their feeding rate and health. The cage and pen should not be constructed over waterways used for navigation. Cages can be installed in deeper waters (>4 m), whereas pens should be in shallow waters (1-2 m). Additionally, the materials used must be durable enough to withstand severe weather conditions and prevent the inflow of debris, while allowing for the free flow of water out of the system and excess feed that would otherwise pollute it. Often, farmed fish rely on natural live foods within their environment, augmented with artificial feed, when stocking densities are high, which is a common practice in such systems.

Figure 10 Photography of Fish Cage Set-up; (Source – Everlush.ng)

Issues of Fish Welfare with Cages and Pens

- The system is vulnerable to environmental pollution from the surrounding water body. Also, other environmental hazards and predators will stress the fish.
- Use of poor-quality material may create tears and openings for other unintended stray fish species, predators or aquatic animals' access to the cages and pens, and these could hurt farmed fish, introduce extraneous pathogens and diseases to farmed fish, and vice versa.

- Conflicts in the use of waterways and upstream activities could lead to disruption of maintenance activities and disturbances to the fish in cages and pens.

Stocking Density

Stocking density, essentially the amount of fish present per unit of water volume (kg/m^3), is a critical factor in fish welfare. Overcrowding, a consequence of high stocking densities, can lead to increased competition for resources like food and oxygen, traumatic injuries from each other, leading to stress, aggression, and even disease outbreaks. This can significantly impact fish growth rates and survival. On the other hand, excessively low stocking densities can result in inefficient resource utilisation and lower overall production.

Several factors influence optimal stocking density. These include the specific fish species being cultured (e.g. tilapia, catfish), their life stage (juveniles, adults), the type of rearing system (e.g. earthen ponds, cages), water quality conditions, and the feeding regime.

Determining the ideal stocking density requires careful consideration and analysis. Accurate measurement of water volume in the rearing system is crucial for effective management and control. Continuous monitoring of fish growth rates is essential, allowing for adjustments to stocking densities as the fish grow. Furthermore, consulting research-based guidelines and seeking advice from experienced fish farmers will provide valuable insights for optimising stocking densities and ensuring the well-being of the fish.

Determining Stocking Density

The number of fish to stock depends on several key factors, including the desired production level, the size of the fish at harvest, the growth rate of the species, water

quality management capacity, and the type of culture system (e.g. extensive pond, semi-intensive pond, tank).

A basic approach to estimate the initial number of fish to stock involves working backwards from the desired harvest weight and considering survival rates:

1. ***Determine Desired Harvest Weight:*** Decide on the total weight of fish you want to harvest from your pond or tank in a given cycle. Let's say you aim for 100kg of harvestable fish.
2. ***Estimate Average Harvest Size:*** Determine the average weight each fish will reach at harvest. For example, if you are growing tilapia to an average of 200grams (0.2kg) per fish.
3. ***Calculate the Number of Fish to Reach Harvest Weight (Without Considering Mortality):***
    - Number of fish = Desired Harvest Weight (kg)/Average Harvest Size (kg/fish)
    - Number of fish = 100 kg / 0.2 kg/fish = 500 fish
4. ***Estimate Expected Survival Rate:*** Based on your experience, the species you are growing, and your management practices, estimate the percentage of fish that are likely to survive to harvest. For example, if you expect an 80% survival rate, it means that for every 100 fish stocked, 80 will likely reach harvest.
5. ***Calculate the Initial Number of Fish to Stock (Considering Mortality):*** To account for the expected mortality, you need to stock more fish initially.
    - Initial Stocking Number = Number of Fish to Reach Harvest Weight/Expected Survival Rate (as a decimal)
    - Initial Stocking Number = 500 fish/0.80 = 625 fish

Therefore, to harvest 100kg of tilapia at an average size of 0.2kg with an expected 80% survival rate, you would need to stock approximately 625 fingerlings.

Importance of Accurate Stocking Density

Properly determining and managing stocking density is crucial for:

- ***Fish Welfare:*** Overcrowding leads to increased stress, competition for resources (food, oxygen, and space), and a higher risk of disease outbreaks.
- ***Growth and Productivity:*** Optimal stocking density allows for efficient feed utilisation and maximises fish growth while minimising competition.
- ***Water Quality:*** Overstocking can quickly degrade water quality, leading to high levels of ammonia and other waste products, which can harm the fish.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- Discuss each of your current growing systems for your fish farms. What problems are you facing on your farm?
- Did you do any analysis or evaluation of your farm sites before you decided? Please share your findings and explain why you chose your current system.

- Based on what has been learned so far, how do you intend to improve the growing system and site of your farm to align with good fish welfare practices?
- Discuss your current stocking density (if you know it).
- Did you consider stocking density before starting your fish farm? How do you determine the optimal stocking density for it?
- Based on what has been learned so far, what challenges have you been experiencing, and how do you intend to improve your fish farm stocking density going forward?

MODULE 5 – WATER QUALITY AND FISH WELFARE

This module explores the impact of water quality on fish welfare and how to effectively monitor this crucial factor to ensure the health and well-being of fish.

Introduction to Water Quality

Water quality is a paramount factor for fish welfare in Malawian aquaculture systems. Fish are intimately associated with their aquatic environment, and fluctuations in water quality can have significant impacts on their health, growth, and survival.

Key water quality parameters that require careful monitoring include:

- Temperature, which affects body temperature fluctuations from the surrounding water.
- Dissolved oxygen, which is crucial for fish respiration.
- pH of the water, which significantly influences fish physiology and can affect nutrient uptake and disease susceptibility.
- Ammonia and nitrite, which are toxic to fish, even at low concentrations.
- Nitrate, which has high nitrate levels and can still negatively impact fish health even though it is less toxic than ammonia and nitrite.
- Conductivity, which indicates the total dissolved salts in the water.
- Turbidity as an indication of suspended solids.

Water flow plays a critical role in maintaining water quality. It facilitates the exchange of oxygen, dilutes accumulated waste products (e.g. ammonia, uneaten feed), and helps to distribute nutrients evenly throughout the rearing system. Adequate water flow ensures proper oxygenation and removal of waste

products. Proper water flow patterns within the rearing system are essential to prevent the formation of "dead zones" where water stagnation can lead to oxygen depletion and the accumulation of toxic substances.

Modern aquaculture systems often rely on technological equipment such as aeration, filtration, and water recirculation systems to maintain optimal water quality. Regular maintenance and monitoring of these systems are crucial to prevent equipment malfunctions, which can rapidly deteriorate water quality and negatively impact fish health.

Considerations for Optimal Fish Health and Welfare

Water quality is one of the most crucial factors affecting fish health, and their entire existence depends on the water environment in which they live. This makes fish very sensitive to pollution and poor water quality issues. On the other hand, they will flourish and remain in good health in an optimal water environment that suits them. To ensure good water quality for optimal fish health and welfare, the following must be taken into consideration:

- **Water Source and Quality:** The source of water used for aquaculture operations should be of high quality, ideally resembling the natural environment of the cultured fish species. Water sources should be free from pollutants, chemicals, and infectious organisms.
- **Water Budget and Management:** Effective water budgeting is vital to guarantee an adequate and reliable water supply. Measures must be taken to prevent potential water shortages, as insufficient water can cause heightened stress, lower oxygen levels, and ultimately, higher mortality.
- **Regular Water Quality Monitoring:** Continuous monitoring of key water quality parameters is crucial because it provides early warning signals for potential fish health risks, so that appropriate mitigation measures are put in place as one of the fish welfare requirements. Regular monitoring of physical

parameters such as temperature, pH, dissolved oxygen, ammonia, nitrite, nitrate, and turbidity is essential. Regular testing for organic and inorganic contaminants, as well as potential pathogens, should also be conducted regularly.

Life Stage and Species-Specific Considerations

Water quality is a crucial aspect of fish welfare in any aquaculture system. Different fish species at different life stages have unique water quality requirements. The table below provides a general overview of the optimal water quality parameters for commonly farmed species in Malawi, including tilapia (e.g. *Oreochromis shiranus, Oreochromis karongae, Coptodon rendalli, Oreochromis mossambicus*) and catfish (e.g. *Clarias gariepinus*). For example, catfish, particularly *Clarias gariepinus*, are among the most widely farmed species in Malawi. While known for their hardiness and adaptability, their welfare is significantly influenced by water quality. Unlike tilapia species, catfish possess accessory respiratory organs (arborescent organs) that enable them to breathe air directly. This adaptation enables them to survive in environments with low dissolved oxygen levels, contributing to their reputation for resilience and hardiness. However, this does not negate the importance of maintaining optimal water quality for their well-being. Exposure to poor water quality can lead to stress, disease, and reduced growth rates in catfish.

Table 2 Table of Water Quality Parameters for Tilapia and Catfish

Water Quality Parameter	Optimal Range for Tilapia	Optimal Range for Catfish	References
Temperature (°C)	25-30	25-30	Boyd, C.E., and Tucker, C.S. (2020).
Dissolved Oxygen (mg/L)	5 - 7.5	>4	Mudege N.N., *et. al*…, 2021.
pH	6.5-8.5	6.5-8.5	BORGES, A.M., 2009.

Ammonia (mg/L)	<0.02	<0.05	Boyd and Tucker, 2020
Nitrite (mg/L)	<0.1	<0.5	Boyd and Tucker, 2020
Nitrate (mg/L)	<100	<150	Boyd and Tucker, 2020
Turbidity (NTU)	<50	<100	Boyd and Tucker, 2020

How to Measure and Correct Water Quality Parameters

Measuring water quality is essential for maintaining a healthy aquatic environment. Farmers can use various testing kits, electronic meters, or send samples to a water quality laboratory for more comprehensive analysis. For accurate measurements, follow the instructions provided with the test kit.

Solutions for Out-of-Range Parameters

When any of the water quality parameters fall outside the desired range, farmers must take immediate action to correct the issue. On a general note, after removal of the agent causing the water parameter imbalance, partial/full water replacement with water of desirable parameters can salvage most parameters; this needs to be done in such a way that minimises stress/shock to the fish. In addition, here are some parameter-specific measures to correct out-of-range water quality parameters:

- **Dissolved Oxygen:** Low oxygen levels are a frequent and critical issue leading to immediate stress and mortality due to factors like high organic matter decomposition, overstocking in often stagnant ponds, and high temperatures reducing oxygen solubility.
- **Ammonia, Nitrite, Nitrate:** The buildup of these toxic nitrogenous wastes due to inadequate biological filtration in simple pond systems and high organic loads from manure use is a significant concern affecting fish health and survival.

- **Temperature:** Managing excessively high temperatures, particularly during the hot season, poses a significant challenge as active cooling with chillers is largely impractical. High temperatures exacerbate oxygen issues and stress fish.
- **Turbidity:** While not always directly lethal, persistent turbid water from soil erosion or suspended organic matter is a common problem that reduces light penetration, hinders primary productivity, and can stress fish by affecting visibility and potentially clogging gills.
- **pH:** While pH imbalances occur, particularly in acidic soils, the practical use of agricultural lime to raise pH is a relatively known and accessible intervention for many farmers, making extreme and unmanaged pH issues potentially less widespread than oxygen or ammonia problems.
- **Alkalinity and Hardness:** Direct measurement and adjustment of alkalinity and hardness are less common practices among small-scale farmers in Malawi. While important for pH stability, they are often implicitly managed through liming and the characteristics of the water source.
- **Total Dissolved Solids and Salinity:** High TDS is likely more relevant in specific geological areas or with certain water sources, but widespread salinity issues requiring reverse osmosis are not a typical concern for the predominantly freshwater aquaculture in Malawi. Regular water changes, where feasible, are the primary method for managing TDS.

To reiterate, it is beneficial to always refer to species-specific water quality guidelines and adjust water parameters gradually to avoid stressing the aquatic organisms. Regular monitoring of water quality is crucial to prevent issues before they escalate. *If you encounter persistent problems or are unsure about the appropriate solutions, consult with an experienced veterinarian, aquaculturist, or aquatic biologist for personalised guidance*.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- Discuss your previous knowledge and experience with good and bad water quality.
- Have you been monitoring water quality? If yes, how?
- Based on what you have learned so far, what issues have you experienced with water quality, and how do you intend to improve the water quality on your farm to align with good fish welfare practices?
- How can you better measure water quality on your farm? What parameters are most important to you?
- Do you keep water quality monitoring and other records at your farm? If yes, what do you do with such records
- Discuss in groups the importance of record keeping and make presentations.

MODULE 6 – FEEDING AND FISH WELFARE

This module provides general welfare considerations and guidelines for feeding fish in aquaculture systems, focusing on best practices, feed composition, and feed quality.

General Best Practices for Feeding

Feeding is a crucial aspect of fish farming, significantly impacting fish health and welfare. To ensure optimal fish growth with minimal stress and enhanced overall well-being, the following best practices should be implemented:

1. **Feeding Frequency and Quantity**
    - Establish consistent feeding schedules and avoid prolonged periods of starvation (exceeding 72 hours).
    - Provide adequate amounts of feed to meet the nutritional needs of the fish without overfeeding. Underfeeding can stunt growth and compromise fish health, while overfeeding can lead to poor water quality, increased disease risk, and environmental pollution.
2. **Feed Quality and Presentation**
    - Use high-quality feeds that are appropriate for the species and life stage of the fish.
    - Avoid feeding excessively large pellets, as smaller fish may not be able to consume them effectively.
    - Ensure that all fish in the pond or enclosure have access to the feed.
3. **Feeding Strategies**
    - Consider feeding strategies that minimise competition among fish, such as distributing feed evenly throughout the pond or using multiple feeding points.

- Periodically vary the feeding locations within the enclosure to encourage natural foraging behaviour and minimise stress.

4. **Sustainable Feed Practices**
    - Explore the use of locally available and sustainable feed ingredients, such as insect larvae or plant-based protein sources.
    - Consider integrating aquaculture with other farming practices (e.g. integrated aquaculture-agriculture) to improve resource utilisation and reduce environmental impact.

Composition and Quality of Feed Ingredients

Fish feed ingredients must be of the highest quality, free from any contaminants, and possess desirable taste and aroma. A balanced diet is crucial, encompassing appropriate levels of protein, carbohydrates, fats, oils, and minerals. The use of feeds containing growth hormones is strictly prohibited. A well-formulated fish feed recipe incorporates a variety of ingredients to ensure balanced nutrition, promoting optimal growth and development (Mushagalusa et al., 2020). The feed should be in pelleted floating form to prevent waste and ensure consistent nutrient delivery. It is crucial to match the pellet size to the catfish's mouth size, gradually increasing the size as the fish grow to facilitate proper consumption and prevent choking. These factors contribute to efficient feed utilisation and healthy growth in catfish farming.

Fish Feed and Specific Welfare Considerations

Providing appropriate and nutritious feed is fundamental to ensuring the welfare of farmed fish. Beyond mere sustenance, the type, source, and management of fish feed have significant implications for their physiological health, behaviour, and overall well-being. This section will examine the crucial connection between fish feed and specific welfare considerations, emphasising the significance of dietary

composition, feeding practices, and the ethical sourcing of feed ingredients in fostering a good life for aquaculture species.

1) Minimising the use of animal-based ingredients in fish feed is paramount for both animal welfare and environmental sustainability. Prioritising terrestrial, other aquatic (excluding wild-caught and high individual-to-weight ratio species), and insect-based ingredients is essential. Wild-caught fish and small animals with high individual-to-weight ratios (like insects and krill) should be avoided due to their significant impact on wild populations and marine ecosystems. Furthermore, the reliance on fishmeal and fish oil often contributes to overfishing and can be economically volatile. Producers must transition towards alternative feed sources with:

a) **High Feed Efficiency:** Maximising nutrient utilisation while maintaining fish health and nutrition.
b) **Herbivorous Species:** Substituting carnivorous farmed species with herbivorous extractive species.

2) Feeding fish with chicken offal or maggots is strongly discouraged due to high zoonotic disease risks and ethical concerns. This practice should be discouraged through advocacy for national and Africa-wide animal welfare regulations.

3) Adhering to recommended daily feeding rates, typically ranging from 2-5% of the fish's body weight, is a fundamental practice for ensuring optimal fish health and welfare. While feeding practices can vary based on species, culture facilities, and management approaches, consistently applying scientifically determined feeding rates is crucial to provide adequate nutrition without risking overfeeding and the associated negative impacts on water quality and fish physiology. Factors influencing feed consumption, and thus the application of these rates, include fish health status, water quality parameters (such as temperature, pH, and oxygen

levels), feed quality (including taste, size, and palatability), and the chosen feeding method. Regular monitoring of fish behaviour, growth rates, and uneaten feed, coupled with meticulous record-keeping, remains essential for fine-tuning feeding regimes and promptly addressing any deviations from healthy patterns.

4) Proper feed storage is essential to maintain quality. Feeds must be protected from moisture, heat, mould, and contamination. Storage areas should be secure from rodents, insects, birds, and other animals. Humidity is a crucial element that must be controlled or managed to store fish feed properly. High levels of humidity could lead to contamination of the feed (by fungal substances) and reduce its nutritional value (Mushagalusa J. *et. al.* 2020).

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- Discuss your previous knowledge and experience with good and bad feed.
- How do you differentiate between good and bad feed for your fish?
- Based on what you have learned, what experiences have you had in the past with sourcing feed for your fish?

- How do you intend to improve the feeding on your farm to align with good fish welfare standards?
- What local alternatives do we have to poor, unethical feeding practices, such as:
    - Use of smaller animals for fish feed,
    - Use of hormones,
    - Use of chicken offal and maggots, and
    - Use of insects?
- How can we innovate on alternative feeding that meets optimal welfare standards for fish production?

MODULE 7 – FISH WELFARE DURING HANDLING AND TRANSPORTATION

Handling and Fish Welfare

Handling and transporting fish are essential yet potentially stressful procedures in aquaculture, necessary for tasks such as stocking, vaccination, grading, and marketing. Ensuring the health and welfare of farmed fish during these activities is paramount, not only for ethical reasons but also for producing high-quality products. This module will address critical techniques to minimise stress and safeguard fish well-being throughout the production cycle, providing practical guidance tailored to the specific challenges and resources of Malawi's aquaculture industry, ultimately optimising both fish welfare and product quality.

Welfare Considerations in Fish Handling

Fish are very sensitive to handling, and the removal of fish from water elicits a maximal emergency stress response. Therefore, animal welfare groups and organisations advise that handling should be kept to an absolute minimum, and the removal of fish from water should only be carried out when absolutely necessary, for no longer than 15 seconds, unless the fish is anaesthetised (Humane Slaughter Association, 2005). Building on this, it is essential for the aquaculture industry to continually develop less stressful methods for carrying out on-farm procedures that involve fish capture, handling, and transportation.

Fish are highly sensitive to handling, and water temperature is a critical factor influencing this sensitivity. Handling should be minimised or avoided during high water temperatures due to increased metabolic stress and oxygen demand, which can lead to poor recovery and increased risk of mortality. Similarly, very low temperatures also stress fish, making them less resilient to environmental changes. Crucially, handling fish at or below freezing temperatures is severely detrimental and must be avoided entirely due to the risk of tissue damage and death. Therefore, understanding the specific temperature tolerance of the fish species

and conducting handling procedures only when water temperatures are within the optimal or tolerable range is essential for minimising stress and ensuring their welfare.

Poor handling may cause injuries to eyes, fins, and muscles, as well as scale loss. It also damages the skin's protective mucous coating, which serves as the primary line of defence against pathogens, thus increasing the vulnerability of fish to disease. Furthermore, all equipment used for handling must be in a good hygienic condition and, if possible, have a plain surface structure to avoid fish injury.

Transportation and Fish Welfare

Transporting live fish is a complex process that often involves long distances over challenging roads, exposing the fish to significant stress. From the initial capture and preparation, through loading, transit, and unloading, each step presents welfare concerns. The stress response in fish, comparable to that of mammals and birds (Fish Count, 2019), can be prolonged, with recovery taking upwards of 48 hours for some species. In Malawi's hot climate, this stress is amplified.

The physiological effects of transport stress include metabolic, hormonal, and behavioural changes, significantly impacting fish health. Critically, stress weakens the immune system and disrupts osmoregulation, leading to increased susceptibility to diseases prevalent in local waters. This is a major cause of mortality during transport, a serious concern for Malawian fish farmers. For many species, the initial loading process is particularly stressful.

Practical challenges, such as the availability and cost of oxygen gas, limited access to specialised transport vehicles, unreliable electricity for oxygenation and temperature control, and variable weather conditions, exacerbate these issues. To mitigate stress, farmers should prioritise gentle handling during capture and loading, avoid overcrowding, and strive to maintain optimal water quality during

transit. This includes utilising available resources for oxygenation, such as locally made aeration devices, and transporting fish during cooler times of the day. Given the economic reliance on aquaculture, minimising transport stress is not just an ethical concern but a critical factor for sustainable livelihoods.

Welfare Considerations in Fish Transportation

Transportation of live fish presents significant welfare challenges. Farmers utilise various capture and movement methods, from small nets to fish pumps. However, nets can cause abrasions and scale loss, while poorly designed pumps can lead to injuries. Unlike ideal scenarios, where specialised vehicles are available, many Malawian fish farmers rely on basic transportation methods, such as open buckets on bicycles or open trucks, which pose substantial stress to the fish.

Practices like transporting fish in uncovered containers under the hot sun or starving them to minimise water pollution are common but detrimental to fish welfare. These methods lead to overcrowding, poor water quality, and limited oxygen, all of which trigger a severe stress response in the fish.

While the ideal method for transporting delicate fish seed involves sealed polyethylene bags within insulated boxes and preparing oxygenated quarantine tanks, Malawian farmers often operate under significant resource limitations. To adapt and improve existing practices, they can implement the following feasible strategies:

- **Utilise locally sourced insulation:** Instead of expensive insulated boxes, farmers can line their transport containers (such as sturdy plastic basins or woven baskets) with readily available insulating materials like layers of banana leaves, thick cloth or sacks (which can be dampened), tightly packed dry grass, or maize husks. This provides a crucial buffer against rapid temperature changes during transit.

- **Optimise transport timing:** To mitigate temperature stress, transporting fish seed during the cooler hours of the day, such as early morning or late afternoon, can significantly improve survival rates. Avoiding the heat of midday is essential.
- **Employ basic aeration methods:** Where dedicated oxygen cylinders are unavailable, simple aeration techniques can be employed. Battery-powered portable aerators, if accessible, can provide vital oxygen. Alternatively, manually agitating the water in the transport bags or containers at intervals can help temporarily increase oxygen levels.
- **Implement rudimentary quarantine:** Even without dedicated quarantine tanks, farmers can utilise existing clean tanks or large containers filled with oxygenated water for a basic quarantine period. This allows for observation of the fish seed for any signs of stress or disease before introducing them to the main culture system.

Stress during transport arises from pre-transport treatments, such as pond draining, loading, and the journey itself, where water quality deteriorates due to limited oxygen and the accumulation of ammonia and carbon dioxide. Temperature fluctuations, especially in hot climates, are a major concern. Lowering water temperature can increase stocking density, but abrupt changes are highly stressful (Fish Count, 2019).

To align with evolving scientific understanding of fish sentience and the importance of minimising stress, and considering the potential for accessible solutions like clove oil to improve handling and transport welfare in aquaculture, Malawian policy frameworks should explore and support the development of guidelines for the safe and sustainable use of appropriate anaesthetic methods.

The World Organisation for Animal Health (WOAH) has published general welfare guidelines, offering valuable information that fish farmers should strive to implement, given their limitations. This includes improving the common practice of

using open containers by providing shade and increasing the amount of water used.

Ultimately, poor transport practices lead to economic losses through increased mortality and reduced product quality. Educating farmers on gentle handling, water quality management, and practical adaptations is essential for improving fish welfare and ensuring the sustainability of the aquaculture sector.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.
If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- How do you currently handle your farmed fish? Please mention all handling methods you use.
- As a fish farmer, have you received training on handling Operational Welfare Indicators (OWIs)? If so, briefly explain who provided it, when it happened, and some examples of how you apply it to your daily routine.
- Based on previous experiences, what is your knowledge of fish transportation? Mention all transportation methods used.

- As a fish farmer, have you received training on transportation OWIs? If so, briefly explain who provided it, when it happened, and some examples of how you applied it before and after live fish transportation.
- Is the person responsible for live fish transportation trained for that purpose?
- Does this person know how to act in frequently encountered situations and emergencies during transportation?
- How do you intend to improve the handling and transportation of your farmed fish to align with good welfare standards? Are there challenges (e.g. economic costs, operational on-farm procedures) preventing you from implementing them?
- How can local innovations in transportation be employed to meet optimal fish welfare standards?

MODULE 8 – SLAUGHTERING AND FISH WELFARE

Overview of Humane Fish Slaughter in Malawi

Unfortunately, inhumane fish slaughter practices remain prevalent in Malawi, particularly in small-scale aquaculture operations, local markets, and household settings. Fish are often subjected to slow methods of killing, such as prolonged exposure to air, which causes significant suffering. Furthermore, the common practice of selling live catfish in markets often involves extended transport without adequate water or food, leading to stress, asphyxia, and temperature shock. These practices not only compromise fish welfare but also hinder the potential for exporting high-quality fish products to international markets with stringent animal welfare standards, such as the European Union and the United States.

The World Organisation for Animal Health (WOAH) Aquatic Animal Health Code provides guidelines on fish welfare during stunning and slaughter, which Malawi, as a member state, is encouraged to adapt for its own national guidelines. While the adoption of humane slaughter methods is still in its early stages in Malawi, there is growing awareness of the need for improvement. Electrical stunning is a promising method as it offers a rapid and effective way to render fish unconscious, minimising pain and stress.

To ensure effective implementation of humane slaughter practices, it is crucial that individuals involved in fish slaughter in Malawi receive proper training and possess the necessary technical skills. They should be able to operate stunning equipment correctly, recognise signs of effective stunning, and understand when re-stunning is required. Regular training, skills development, and evaluation of stunning and slaughter methods are essential, and records of these activities should be maintained at aquaculture facilities. As fish slaughter technology and methods continue to evolve, ongoing training and knowledge sharing are vital for ensuring the highest standards of fish welfare in Malawi.

Benefits of Humane Slaughter of Fish

Implementing humane fish slaughter practices in aquaculture offers significant advantages for the fish, fish farmers, and consumers. These benefits are outlined below:

- **Improved Fish Welfare in Malawi:** Reduced stress minimises pain and suffering in the fish.
- **Improved Meat Quality and Reduced Spoilage (Food Safety):**
    - Humane slaughter methods contribute to higher quality fish fillets, minimising issues like soft flesh, gaping, bruising, and scale loss (Fish Count, 2019). This leads to an extended shelf life compared to traditional, less humane methods (Holmyard, 2017).
    - Fish slaughtered humanely often exhibit firmer, translucent fillets with brighter colours, and the onset of rigor mortis is delayed (Humane Slaughter Association, 2019). This is very important for the fish industry, as it will reduce losses and increase the value of the fish.
- **Enhanced Consumer Confidence and Improves Consumption of Fish and Fish Products:** Reducing stress during slaughter through humane methods is likely to improve the eating quality and taste of fish for consumers in Malawi.
- **Increased Ethical Value and Potential Economic Gain:**
    - Adopting humane slaughter processes enhances the ethical value of fish products, potentially commanding higher prices (Fish Count, 2019).
    - As awareness of animal welfare grows in Malawi, consumers may be willing to pay a premium for humanely produced and slaughtered fish.
- **Improved Regulatory Compliance and Market Value:**
    - Practising humane slaughter methods improves compliance with local and potentially future global food processing and safety standards, which can enhance the market value of fish products.

Pre-Slaughter Welfare Considerations

The Humane Slaughter Association provides recommendations for pre-slaughter welfare considerations, which are detailed as follows:

Purging (Fasting)

- Purging, or withdrawing feed before slaughter, is crucial to empty fish guts, reducing contamination risks during processing and maintaining product quality.
- A 24 to 48-hour fasting period is generally recommended, but water temperature significantly impacts gut clearance time.
- In the warm climate of Malawi, especially during the hot season, shorter fasting periods might be sufficient. This should be validated by local research.

Crowding

- Crowding, often used during harvesting, can cause stress and reduce oxygen availability.
- To minimise stress, crowding should be gradual, and oxygen levels should be monitored and supplemented if necessary.
- Fish should not be crowded for more than two hours.
- A dedicated staff member should monitor the crowding pen to ensure fish welfare.
- When possible, crowd pens should be set up so that fish can swim toward the inlet pipe, ideally in a shaded area.
- In Malawi, many small-scale fish farms use small ponds, so crowding happens on a small scale. However, the same rules apply.

Dewatering

- Dewatering, the transition from crowding to stunning/slaughter, is stressful as fish are removed from their natural environment.

- To reduce stress, dewatering should occur as close to the stunning point as possible.
- Humane dewatering methods include: using aquatic anaesthetics, pumps, and braille nets.
- In Malawi, many fishers still use traditional nets, so education about humane dewatering is very important.
- The dewatering process should be designed to move fish gently and promptly to the stunner in the correct orientation.

Common Fish Slaughter Methods

Air Asphyxiation: This is the oldest method of slaughter for fish, where they are removed from the water and allowed to die through asphyxiation. It is considered inhumane because it can take the fish over an hour to die. Nile Tilapia and African Sharptooth catfish fall within the category of fish that are quite resistant to hypoxia and take a long time to die. This is especially true for African catfish because they can breathe atmospheric air to some extent, which means they take even longer to die. Additionally, the rate at which oxygen is depleted is dependent on ambient temperature and the rate of fish activity. For example, at 20°C, rainbow trout experience brain death in about 2.6 minutes and cease moving in 11.5 minutes. At 14°C, the same processes require 3 and 28 minutes, respectively. Since the body temperatures of fish vary according to ambient temperature, reducing the temperature of their bodies typically prolongs the time to anoxia and, therefore, the time to insensibility, lengthening the period of distress. Also, fish that evolved from low-oxygen environments take longer to die, while at higher temperatures, fish lose consciousness more quickly. Another major drawback of the asphyxiation method is that it diminishes meat quality and shelf life.

Head Strike and Stunning: Also known as manual percussion, this is one of the traditional methods for stunning and slaughtering fish. In this method, fish are

removed from the water and given a sharp blow to the head. If the blow is strong, the animal is slaughtered. If the blow is weak, the animal is stunned. Worse still is cracking of the skull with a heavy instrument or hitting the skull on a hard surface. After the blow is engaged, the fish usually bleeds. Percussive stunning, a recommended stunning method, involves a forceful and accurate blow to the head with a blunt instrument. The force required will depend on the size of the fish. The blow should be aimed just above the eyes to impact on the brain. The effectiveness of the stun should be checked, and another blow applied if the fish is not unconscious.

The main disadvantages are the unethically violent nature of the method and the often stressful handling of the fish before the slaughter or stunning process. In this case, fish undergo pain and rigour, thereby affecting their flesh and taste even after the processing. Also, there are high failure rates in some fish (such as catfish), as they may remain conscious or retain body movement and sensibilities despite such head strikes.

Spiking: Another crude traditional method is spiking, which involves inserting a sharp spike (such as an ice pick or a sharpened screwdriver) directly through the head of the fish into the brain. The procedure can be applied more accurately in large fish due to the larger size of their brains. In smaller fish, the brain may be difficult to locate and destroy. If it is not destroyed, the fish will undergo stress, and some undesirable changes in meat quality may result. For optimal results, the spike should be positioned to penetrate the skull and then inserted quickly and firmly into the brain. The impact of the spike should produce immediate unconsciousness. The spike should then be moved from side to side to destroy the brain. The main disadvantage here is also the unethically violent nature of the method. It is important to note that manual spiking requires a lot of precision and expertise to be efficient. Therefore, if you must choose between manual

percussion (striking) and manual spiking, manual percussion is probably easier to implement effectively because it requires less precision.

Live Chilling: Live chilling is considered a valuable practice in the aquaculture industry, as it offers the advantage of sustained carcass quality. Reducing muscle temperature to near 0°C helps delay enzymatic and microbial spoilage processes. It also increases the time for the onset of rigor mortis and the resolution of rigor. Another advantage is that water can be drained, and the fish placed in an iced container with their temperature lowered. Also, the method immobilises the fish so they can be more easily handled. However, some believe the technique is unacceptable since it prolongs the period of consciousness and does not reduce the animals' ability to feel discomfort. Because chilling slows metabolic rate and oxygen needs, it may prolong the duration until death in some instances, with some cold-adapted species taking more than an hour to die.

In Malawi, farmers may use basic, crude methods by pouring ice blocks directly on the fish, but this leads to a slow and painful death, causing systemic shock to the fish.

Exsanguination (Bleeding to death): This is the process whereby an animal bleeds to death. Fish are cut in highly vascular body regions, and the process is stressful and painful ***unless the animals are first rendered unconscious***. One advantage for the industry is that bleeding prevents the fish muscles from turning an unpleasant red colour and acquiring a bloody odour. The main disadvantage is that if stunning is not done before bleeding according to behavioural and neural criteria, fish may remain conscious for 15 minutes or more between the times when major blood vessels have been cut and when they lose consciousness.

Bleeding can be accomplished by three major processes: cutting the gills, removing the gills or severing the caudal artery. Alternatively, the heart can be pierced, or the blood vessels in the tail can be severed. The animals die from

anoxia, and any struggling, which can range from four to 15 minutes, serves to hasten death. However, some species may live longer – for example, eel brains may continue to process information for 13–30 minutes after being decapitated.

Additionally, bleeding can be achieved with decapitation, and while not encouraged due to the unethically violent nature, it provides the most profuse bleeding and the shortest time before loss of consciousness.

Use of Anaesthesia: An advantage of using anaesthesia is that, once fish are anaesthetised, death can be accomplished more easily by other slaughter methods. Another major advantage is that the fish do not undergo stress, which helps to maintain post-harvest quality. However, the use of anaesthetics raises a major concern that some of their compounds may be absorbed into the animal flesh, leaving residual chemical traces in the muscle tissues that humans and animals would consume. Also, some species may show adverse reactions for a short time to anaesthetics because they appear to be irritating. The efficacy of this method may vary depending on the dosage and the species. For example, African Sharptooth Catfish appear to be very resistant to Aqui-S, i.e. they have shown to become paralysed while still being conscious at doses which are known to be lethal to salmonids. For many species, there is still considerable uncertainty as to whether chemical anaesthesia actually results in loss of consciousness or whether it merely causes fish to become paralysed. For this reason, it is considered that chemical anaesthesia could potentially be humane, but there is too much uncertainty to recommend it.

Nevertheless, different countries have varying regulations regarding the use of pre-slaughter chemical anaesthesia for fish intended for human consumption. Some countries allow it without any withholding period or maximum residue concentration, and some countries have standards on both of those aspects. All

these points lead back to the uncertainties associated with the use of anaesthesia.

Carbon dioxide narcosis: This slaughter method involves dissolving carbon dioxide in the water prior to the introduction of the fish. After that, they react violently while their blood rapidly absorbs the gas. The fish may acquire bruises from hitting each other or the sides of the container. The time required to become anesthetised can vary from less than 4 to more than 100 minutes, and fish may be removed once movement stops, typically after 2-3 minutes. However, there is concern that fish may be rendered immobile by the carbon dioxide before completely losing consciousness and may be bled or eviscerated while still sensible. Also, adding a lot of carbon dioxide to water lowers the pH, making the water very acidic, which causes distress to fish.

Some countries have used nitrous oxide ("laughing gas") instead of carbon dioxide, as it does not cause the strong activity seen in fish immersed in carbon dioxide-saturated water. Nevertheless, the fish recover quickly when removed from contact with the gas.

Electrical Stunning: Stunning by use of electricity is known as electronarcosis, whereas killing by electricity is known as electrocution. Electrical shock using either alternating or direct current has received substantial interest in recent years. Electric stunning is reversible, as normal brain function is disrupted for only a short period. Hence, electronarcosis must be immediately followed by bleeding. Electrocution destroys brain function and, therefore, renders the animal unconscious while stopping the breathing reflex from functioning. For electrical stunning to be effective, proper current and stun duration must be maintained. Also, water factors such as conductivity and temperature must be properly managed.

This method has gained substantial support due to concerns for the ethical treatment of animals and their immobilisation (used in other slaughter methods), which requires mechanical or hand processing. It also prevents stress and struggling before slaughter, which helps to maintain quality.

A potential risk of electrical stunning methods is inflicting pre-stun electrical shocks (which are electrical shocks that fish will consciously endure without losing consciousness). Pre-stun shocks can happen for the following reasons:

1) The electrical parameters are not adequate.

2) The way the electrical shock is applied is not adequate, because:

   a. The current is applied on a part of the fish's body far away from its brain, e.g. its tail.
   b. The current loses its strength because of the resistance of fish bodies: if it is applied in such a way that it has to go through the bodies of some fish before reaching other fish.
   c. When performed in water, the electrical parameters are not suited to the water conductivity.
   d. When performed in water, the way the current is applied makes it so that the resulting electrical field is not homogeneous.

Although electrical stunning is among the most humane available methods, not all electrical stunning methods are good. Acceptable electrical stunning methods include:

- In-water pipeline electrical stunning;
- Head-to-body dry/semi-dry electrical stunning;
- In-water batch electrical stunning.

Unacceptable electrical stunning methods include:

- Batch electrical stunning in an electrical tank without any water;
- Prod electrical stunning with or without any water.

Recent advances in electrical equipment design have made substantial improvements in preventing or minimising undesirable physical and biological effects in treated fish. However, the use of electronarcosis and electrocution remains a challenge in many developing nations due to the expensive setup and inconsistent electricity supply in many of these countries.

Other stunning and slaughter methods include: **Salting** to slaughter fish, which is also considered an inhumane method, as it exposes the fish to pain and suffering because death is not immediate; **use of ammonia baths**; **shooting,** which is often done for large fish; **using a pneumatic accurate gun,** which can deliver the required velocity for effective stunning.

Generally, the WOAH Aquatic Animal Health Code particularly considers air asphyxiation, ice bath, CO_2 narcosis, and exsanguination ***without stunning*** as inhumane. Overall, research continues in the search for the most humane slaughter methods for farmed fish, while fundamental technical issues still need to be resolved for some species.

Overview of Slaughter Processes in Malawi

In Malawi, especially in small-scale settings and local markets, traditional fish slaughter methods, particularly for catfish, raise serious welfare concerns. Commonly, fish are struck on the head and then have a gill cut for bleeding. This practice does not induce immediate unconsciousness, potentially causing prolonged pain and distress for over ten minutes. Prior to this, fish often endure significant stress from being kept out of water, crowded into small containers, and handled roughly, all of which contribute to their suffering.

Moreover, the common practice of cutting only one gill, instead of both, further prolongs the fish's death, exacerbating their distress. These current methods highlight the urgent need for the adoption of humane slaughter practices in Malawi. This shift would not only enhance fish welfare but also improve the quality of fish products, aligning with ethical standards and potentially opening doors to wider markets.

General Guidance for Humane Slaughter Methods for Fish

Humane fish slaughter in Malawi should prioritise methods that induce either an immediate death or instant insensibility to pain until death. This can be achieved through both manual and automated processes, typically requiring fish to be stunned before slaughter. Fish should remain in water until immediately prior to stunning. Generally accepted humane methods applicable to Malawi include: percussive stunning with a club, electrical stunning machines (where feasible), and brain spiking (when performed by skilled personnel). Combining these methods, such as stunning followed immediately by slaughter, can optimise humane outcomes. Effective application necessitates proper design tailored to local fish species and rigorous implementation. Key systems to establish include a well-organised operating cycle to minimise stress duration and intensity, the consistent use of fish stunning to induce unconsciousness, and training personnel to recognise signs of re-consciousness after stunning.

Further considerations for humane slaughter in Malawi involve practical adaptations. When possible, manual pneumatic guns should be favoured over purely manual methods, even if adapted from those designed for other species. Manual percussive stunning is generally preferred over brain spiking unless operators possess the specific skills required for accurate brain spiking. For commercially important fish species in Malawi, technologies exist to enable humane slaughter. It is the responsibility of fish farmers and processors to implement

or adapt these manual or automated technologies to prevent distress and pain during slaughter procedures, thereby improving fish welfare and product quality.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- Do you slaughter your fish? If yes, what procedure do you currently use?
- Based on what you have learned so far, what mistakes have you made with fish slaughter? Mention which of the slaughter methods you have used.
- How do you intend to improve the slaughter of your fish to align with good welfare standards?

MODULE 9 – ENVIRONMENTAL ENRICHMENT AND FISH WELFARE

What is Environmental Enrichment?

Environmental Enrichment (EE) involves enhancing an animal's living environment to promote species-specific behaviours, mental stimulation, and overall well-being. In the context of fish, it refers to creating conditions that mimic their natural habitats and encourage natural behaviours. It can include adding structures or modifying rearing units to create a more natural or complex environment that resembles the fish's natural habitat. It may also include any intentional augmentation of complexity in the surroundings of the animal, such as structures made from plants and pebbles, music, unusual foods, and the introduction of various fish species. Furthermore, it may include mimicking colours and introducing varied conditions like dark hiding spots and cooler water areas for them to choose from (Leone and Estévez, 2008; Näslund and Johnsson, 2014). This is particularly relevant in captive settings such as aquaculture farms and public aquariums (Zhang *et al*., 2020a).
The challenge is determining the type and quantity of environmental enrichment that fish prefer, and this can be aided by understanding their sensory abilities. To get started, we must ensure that each potentially enriching material is pertinent to the biology and preferences of the species. For instance, some fish may prefer hiding, while others may prefer swimming against the flow of the water (Zhang *et al*., 2020a).

Types of Environmental Enrichment

Näslund and Johnsson (2014) outlined commonly recognised spheres of enrichment that can be incorporated into farm enclosures for aquatic animals. Producers should strive to achieve enrichment inclusion in each of these areas where possible.

Social enrichment – This is when animals experience the correct amount and type of contact with other fish or animal species. This includes sufficient access for social species and sufficient distance for those that are mutually aggressive or cannibalistic.

Occupational enrichment – This includes physical and psychological stimulation that allows for the expression of behaviours that promote psychological well-being. This can involve play, interactive feeding opportunities, and sufficient room to swim freely.

Physical/Structural enrichment – This includes modification of housing environments to include structural complexity, shelter, and visual stimulation. This can include adding silt, sand, or other incubation substrates to the floor, which allows animals to burrow.

Sensory enrichment - It aims at stimulating the fish's senses through the use of different stimuli such as light, sound, or odour (Arechavala-Lopez *et al.*, 2019), which is a diversity of visual, auditory, olfactory, tactile, and taste stimuli.

Dietary enrichment- It involves providing a varied and balanced diet to meet the fish's nutritional needs and promote overall health and well-being. The use of feed is enhanced by the addition of appropriate nutrients, the availability of a suitable amount and variety of food, the feeding frequency, and/or the delivery system.

These various types of environmental enrichment can have a positive impact on fish physiology, health, and survival, ultimately enhancing their welfare.

Benefits of Environmental Enrichment

Environmental enrichment (EE) has been shown to have several benefits for fish welfare if applied correctly. These are explained as follows:

- It improves post-stocking survival and foraging efficiency, reduces fin damage, and promotes social cohesion on fish farms (Rosburg *et al*., 2019; Huysman *et al*., 2019).
- It can improve various aspects of fish biology, including aggression, stress, energy expenditure, injury, and disease susceptibility (Arechavala-Lopez *et al*., 2019; Zhang *et al*., 2020b).
- It can have positive effects on fish physiology, health, survival, and general welfare.
- It improves the physiological state and behaviour of fish, serving as an indicator of their well-being (Oliveira *et al*., 2022). This is because it provides new sensorial and motor stimulation to help meet their behavioural, physiological, morphological, and psychological needs, while reducing stress and the frequency of abnormal behaviours (Arechavala-Lopez et al., 2021).
- It also increases spatial use of the tank and enhances growth rate in fish (Zhang *et al.*, 2020a).
- Environmental enrichment enhances the fish's surroundings to avoid negative welfare (like stereotypical behaviour and chronic stress) and encourage positive welfare (natural behaviour display and positive emotions).

Some examples from scientific and evidence-based resources show the impacts and benefits of environmental enrichment. These include:

- Adding structural environmental enrichment to rearing environments has proven positive in reducing aggression, interactions with net pens, and fin erosion in juvenile seabream (Zhang *et al*., 2021).
- Intraspecies aggression in fish can be reduced with increased levels of physical enrichment (Zhang *et al*., 2020b).
- Occupational enrichment, such as providing opportunities for fish to engage in natural behaviours, can help fish cope with acute stressors (Arechavala-Lopez *et al.,* 2019).

Overall, Environmental Enrichment has the potential to improve fish welfare in aquaculture by enhancing their well-being, reducing stress, and promoting natural behaviours. It often requires aqua-ecosystem and biodiversity management, as well as the use and application of local and traditional knowledge (Schweiz *et al*., 2015; Aubin *et al*., 2017).

Species Recommendations for Environmental Enrichment

Catfish

Catfish, a popular aquaculture species in Malawi, benefit significantly from environmental enrichment. To enhance their welfare and promote natural behaviours, it is recommended to provide shelter structures within ponds and tanks. Locally available materials, such as clay pots, bamboo sections, or bundles of reeds, can serve as effective hiding places. Floating pond covers, such as water hyacinth (where it does not become an invasive problem) or shade nets that can provide shade and reduce stress from direct sunlight. Using darker coloured tanks or pond liners can also create a more natural environment, as catfish tend to prefer darker surroundings.

Feeding strategies also play a role in environmental enrichment. At the fingerling stage, providing feed in dry crumbles encourages natural foraging behaviours. For adult catfish, night feeding is preferred, as this mimics their natural feeding patterns. In Malawi, where farmers often rely on locally sourced feeds, varying the feed composition and presentation can provide additional stimulation.

To further guide farmers in implementing these recommendations, Table 1 (Adapted from the Aquatic Life Institute (ALI)) provides a detailed breakdown of environmental enrichment strategies tailored for catfish. This table offers practical advice on shelter, feeding, and other environmental factors that can enhance the well-being of catfish in Malawian aquaculture systems.

Table 3 Environmental Enrichment Recommendation for Catfish Species: African sharp-tooth catfish (Clarias gariepinus)

Enrichment Category	Juvenile	Adult
Enclosure Coloration	For higher survival and better growth in fry, provide black tanks (FishEthoBase)	Not enough information is available currently. Therefore, we default to the species' "natural" conditions at this stage.
Substrate Provision	For the most natural solution, provide vegetation or mud banks (FishEthoBase)	For the most natural solution, provide mud, shale, sand, and vegetation (FishEthoBase)
Lighting	To accommodate the preference for fry and reduce stress in juveniles, provide ≤15 lux. For juveniles, a 24-hour photoperiod is stressful; however, stress decreases, and growth increases with shorter photoperiods. Natural photoperiod is 9-15 hours. (FishEthoBase)	For lower aggression under light intensities of 0.002-1.4 µmoles/m2/s, provide blue light. Natural photoperiod is 9-15 hours. Provide access to natural (or at least simulated) photoperiod and daylight. (FishEthoBase)
Water Augmentation	For better growth in fry, provide shallower than deeper tanks (14.5 diameter-to-depth ratio or 0.1 m2 x 0.03 m depth) (FishEthoBase)	Provide variations in the direction and the velocity of the water inlet, depending on the life stage. Depth: Provide at least 2-4 m, ideally up to 10 m or more, bearing in mind the planned stocking density (FishEthoBase)
Structures	For better growth in juveniles, install bamboo poles in ponds, which probably enable periphyton growth, which serves as additional food (FishEthoBase)	African catfish cultured in a coupled aquaponic system with basil exhibited a reduction in injuries and agonistic behaviour when paired with high plant density compared to low plant density and control conditions (no plants).

Shelter	Shelter structures reduced juvenile cannibalism (Hecht and Appelbaum, 1988; Hossain et al., 1998). Enrichment with shelters probably increases the value for fry, but this may cause attacks and chases to establish territories. (FishEthoBase) Must be carefully monitored.	For the most natural solution, provide vegetation or mud banks; alternatively, provide artificial shelters inside the system or outside (e.g. black plastic shade material, black nylon shade cloth netting, aluminium roof plates. (FishEthoBase)
Feeding System	Juveniles under hand-feeding regimes were more active than self-feeding regimes and showed higher activity during the morning compared to the afternoon.	Night-feeding enhanced growth and lowered feed conversion ratio compared to day-feeding (Boerrigter et al., 2016). Install a belt feeder and provide the majority of feed during the night (FishEthoBase)

Tilapia

Tilapia, a widely farmed fish species in Malawi, benefit significantly from environmental enrichment strategies designed to improve their behaviour and welfare in captive settings. Research indicates that introducing structural elements, such as plant-fibre ropes or physical structures made from locally available materials, can enhance cognition, exploratory behaviour, and brain function in tilapia (Torrezani *et al*., 2013). Furthermore, enriched environments have been shown to reduce aggression and promote the development of natural hierarchical behaviours among tilapia (Arechavala-Lopez *et al*., 2020).

In the context of Malawian aquaculture, these findings suggest that incorporating simple, cost-effective environmental enrichment measures can have a positive impact on tilapia's health and productivity. For example, providing submerged structures using readily available materials like clay pots, rocks, or branches can create hiding spaces and stimulate natural behaviours. Similarly, using plant-fibre ropes or aquatic plants can add complexity to the environment and encourage

exploration.

To provide practical guidance for Malawian fish farmers, Table 2 (Adapted from the Aquatic Life Institute (ALI)) outlines key recommendations for environmental enrichment of tilapia. This table offers specific strategies for creating enriched environments that promote the well-being and natural behaviours of tilapia in aquaculture systems.

Table 4 Environmental Enrichment Recommendation for Tilapia Fish Species Nile tilapia (Oreochromis niloticus)

Enrichment Category	Juvenile	Adult
Enclosure Coloration	Not enough information is available at this time. Therefore, we default to the species' "natural" conditions at this stage.	Maia and Volpato (2016) demonstrated that it takes at least 10 days of testing to determine the colour preference of Nile tilapia, and that green and blue are the most preferred colours by the species.
Substrate Provision	Enrichment with e.g. river pebbles and plastic kelp models probably increases the value for juveniles, but this may cause more intense fights to establish territories (FishEthoBase). Must be closely monitored.	Males tend to choose sand as their nesting substrate over other substrates, such as stones. Individuals presented with an equal frequency of total attacks, whether they were kept with or without substrates; however, fewer highly intense attacks were observed in animals kept with the substrate. For the most natural solution, provide sand and mud; alternatively, provide gravel. Bamboo poles also increase growth (FishEthoBase).
Lighting	Increased light intensity (280-1390 lx) reduces aggressive interactions between pairs of juvenile males.	Natural photoperiod is 9-15 hours. Provide access to natural (or at least simulated) photoperiod and daylight. (FishEthoBase) Blue light reduces stress by preventing the cortisol response associated with

		confinement (Volpato and Barreto, 2001). Natural photoperiod is 9-15 hours. Provide access to natural (or at least simulated) photoperiod and daylight. Avoid 1,400 lux, as it increases aggression compared to 280 lux. (FishEthoBase)
Water Augmentation	Depth: Provide at least 2-6 m, ideally up to 20 m, bearing in mind the planned stocking density. Individuals should be able to choose swimming depths according to life stage and status. (FishEthoBase)	Depth: Provide at least 2-6 m, ideally up to 20 m, bearing in mind the planned stocking density. Individuals should be able to choose swimming depths according to life stage and status. (FishEthoBase)
Structures	An enriched environment increases resource value, which in turn prompts more intense fights (FishEthoBase)	Fish cultured in environments enriched with artificial water hyacinth and shelter presented higher latency to trigger confrontations, and the confrontations were less intense in the section with enrichment items (Neto and Giaquinto, 2020).
Shelter	An enriched environment increases resource value, which in turn prompts more intense fights (FishEthoBase)	For the most natural solution, provide roots or submerged branches, bushes, or trees; alternatively, provide artificial shelters inside the system (e.g. artificial reef) (FishEthoBase)
Feeding System	Ensure that you provide sufficient feed from approximately 4 to 8 days after hatching. Self-feeders could prevent stressful food competition (FishEthoBase)	Tryptophan-supplemented food was found to reduce confrontations (Neto and Giaquinto, 2020). Install a self-feeder and make sure all Nile tilapia adapt to it. (FishEthoBase) Provide sand, mud, and bamboo poles so that individuals may search for food. (FishEthoBase)

In summary, environmental enrichment is a powerful and practical tool for enhancing fish welfare in the aquaculture sector. By providing opportunities for

species-specific behaviours, mental stimulation, and improved overall health, farmers can create more natural and stress-free environments for their fish. Recognising the importance of environmental enrichment in captive settings, particularly in the context of small-scale operations common in Malawi, contributes to the ethical treatment of fish and the long-term sustainability of aquaculture practices.

In Malawi, where resources may be limited, it is crucial to focus on cost-effective and locally adaptable enrichment strategies. This includes utilising readily available materials like clay pots, bamboo, rocks, and locally sourced aquatic plants to create hiding spaces and structural complexity. Promoting proper water quality management and natural feeding behaviours also plays a vital role in enhancing fish welfare.

Continued research and collaboration between scientists, aquaculturists, conservationists, and crucially, Malawian fish farmers, will advance our understanding of effective enrichment strategies tailored to local species and conditions. This collaborative approach will ensure that environmental enrichment becomes a standard practice in Malawi's aquaculture industry, contributing to healthier fish populations and more sustainable livelihoods.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- Have you heard about or tried "Environmental Enrichment" before? What was your experience like? What enrichments do you (or someone you know) currently use?
- Based on your current knowledge, how do you intend to improve the environmental enrichment of your fish to align with good welfare standards?
- How can local innovations and traditional knowledge in the environment be employed to meet optimal welfare standards?

MODULE 10 – FISH HEALTH AND WELFARE

Fish Health and Welfare: An Integrated Approach

Understanding the intricate relationship between fish health and welfare is crucial for sustainable aquaculture and responsible fisheries management in Malawi. Fish welfare has been defined in various ways, often in relation to the level of environmental challenge fish face. For fish held in captivity, stressors such as handling, transport, water quality, stocking density, housing conditions and disease can induce a physiological stress response resulting in poor welfare. Fish health, on the other hand, focuses on the absence of disease and the normal functioning of a fish's body.

While distinct, fish health and welfare are deeply interconnected. A fish in good welfare is generally considered healthy, comfortable, well-nourished, safe, and free from pain, fear, and distress. Conversely, poor welfare can lead to stress, which weakens a fish's immune system, making it more susceptible to diseases.

The key difference lies in their focus. Fish health primarily addresses the occurrence, impact, and treatment of diseases and injuries in fish. Fish welfare, however, extends beyond physical health to consider the fish's sentience, emotional capacity, and ability to adapt to its environment. This includes recognising that fish can experience emotions, have needs, and are conscious beings (Nicks and Vadenheede, 2014).

Promoting good fish welfare is paramount in Malawian aquaculture and fisheries for numerous interconnected reasons. Healthier fish exhibit enhanced productivity, faster growth rates, and greater resilience to disease, ultimately boosting yields for both fish farmers and fishers. Furthermore, adhering to good welfare practices results in superior product quality, characterised by improved meat texture, flavour, and overall appeal, thereby potentially increasing market value. Ethical

considerations are also gaining prominence in Malawi, with consumers demonstrating a growing concern for the humane treatment of aquatic animals. Beyond these direct benefits, prioritising fish welfare contributes significantly to the long-term sustainability of aquaculture and fisheries resources. Moreover, access to international markets is increasingly contingent upon demonstrating adherence to robust animal welfare standards.

Therefore, a comprehensive strategy that seamlessly integrates fish health and welfare principles is indispensable. This necessitates a focus on proactive disease prevention through stringent biosecurity measures, consistent maintenance of optimal water quality, and the provision of nutritionally balanced diets. Ensuring appropriate shelter and a suitable environment, including adequate space, appropriate substrates, and stable water conditions, is equally critical. Minimising stress during all handling and transportation stages, as well as implementing humane slaughter methods to reduce pain and suffering, are essential ethical and welfare considerations. Finally, fostering community awareness through education targeted at fish farmers, fishers, and consumers about the fundamental importance of fish welfare is crucial for widespread adoption and long-term impact.

Biosecurity for Fish Health and Welfare

Biosecurity in aquaculture is a critical set of practices aimed at minimising the introduction, establishment, and spread of pathogens. It encompasses a systematic approach to reduce the risk of infectious diseases entering and spreading within and beyond fish farms. Implementing effective biosecurity measures not only safeguards fish health but also reduces stress, thereby enhancing their overall welfare. These practices are essential for maintaining sustainable quaculture production and ensuring the quality of fish products in Malawi. According to Yanong and Erlacher-Reid (2012), the core objectives of biosecurity in fish farms include:

1. **Effective Fish Management**: Procuring healthy fish stocks and optimising their health and immunity through sound husbandry practices. This is particularly important in Malawi, where many small-scale farmers may not have access to high-quality fingerlings.
2. **Pathogen Management:** Preventing, reducing, or eliminating pathogens through stringent hygiene and sanitation protocols.
3. **People Management:** Educating, training, and managing the movement of staff and visitors to minimise the risk of disease transmission.

The likelihood of a pathogen entering a fish farm, spreading between systems, and causing disease is influenced by several factors. These include the fish species, their immune status, their condition (including welfare), and their life stage. Environmental factors such as water quality and chemistry, pathogen characteristics, the presence of disease hosts or reservoirs, and pathogen survival on inanimate objects also play a significant role. Crucially, the skills, understanding, husbandry practices, and adherence to biosecurity principles and protocols by farm workers are paramount.

There are various agents that can introduce and spread diseases on fish farms, and these include:

1. **Fomites (Inanimate Objects):** Nets, buckets, siphons, footwear, clothing, vehicles, and containers can all act as vectors for disease transmission. It is essential to note that in Malawi, many farmers share equipment among their farms.
2. **Vectors (Carriers):** New livestock, predatory birds, pets, and even people can carry and transmit pathogens.
3. **Direct Contact**: Contact with dead or dying fish, other aquatic animals, contaminated feed, and water sources (including on-site sources, water reuse, and transportation sources) can facilitate disease spread.

Benefits and Challenges of Biosecurity on Fish Farms

Malawi's aquaculture sector, while showing promising growth, faces challenges that underscore the critical need for robust biosecurity practices. Disease outbreaks, often exacerbated by limited resources and inadequate knowledge, pose a significant threat to fish farms nationwide. This directly aligns with the fundamental benefit of biosecurity, reducing disease transmission and minimising the spread of diseases within and between farms. In Malawi, where many small-scale farmers share water resources and often lack access to diagnostic services, preventing the spread of disease is paramount.

The limited availability of trained aquatic animal health professionals and the absence of a comprehensive national aquatic animal health strategy in Malawi highlight the importance of enhancing aquatic animal health through proactive biosecurity measures. By implementing preventive measures, farmers can reduce their reliance on costly and often inaccessible veterinary services. The threat of both endemic and imported diseases underscores the need to prevent new diseases in ponds through strict biosecurity protocols.

Disease outbreaks in Malawi can result in severe economic losses, affecting the livelihoods of fish farmers and jeopardising food security. This aligns with the benefit of biosecurity in protecting human health by ensuring food safety. Fish is a vital source of protein in Malawi, and maintaining its safety is crucial. Moreover, the stress caused by disease outbreaks affects fish welfare, emphasising the role of biosecurity in reducing stress and improving fish welfare and well-being.

In Malawi, where many aquaculture operations are small-scale and resource-constrained, the financial impact of disease outbreaks can be devastating. Implementing cost-effective biosecurity measures is essential for preventing financial losses and ensuring the sustainability of these operations. As Malawi seeks

to expand its aquaculture sector and potentially engage in regional trade, demonstrating the implementation of documented biosecurity measures will be crucial for accessing markets and building consumer confidence. The implementation of effective and context-appropriate biosecurity practices in Malawi can strengthen its aquaculture sector, improve fish health and welfare, and contribute to food security and economic development.

Common Biosecurity Measures and Practices for Fish Farms

Establishing effective biosecurity begins with careful site selection and design. In Malawi, where water resources are limited and shared, selecting a reliable and high-quality water source is crucial. Farmers should strive to avoid water sources that are shared with other farms or located near potential sources of contamination, such as agricultural runoff or sewage discharge. If possible, treating or filtering incoming water can further reduce the risk of introducing pathogens. The farm layout itself should be designed to minimise the risk of disease spread between ponds or tanks. Implementing separate areas for quarantine, grow-out, and processing, along with clear traffic flow patterns for personnel and equipment, can significantly enhance biosecurity. Proper drainage and waste management are also essential. Ensuring effective drainage prevents water stagnation and pathogen buildup, while implementing sound waste management systems facilitates the safe disposal of dead fish, uneaten feed, and other organic matter.

Stocking and quarantine are crucial steps in preventing the introduction of diseases onto a fish farm. In Malawi, where access to high-quality fingerlings can be a challenge, sourcing fish from reputable hatcheries with disease-free certification is vital. New stock should be thoroughly inspected for signs of disease before introduction, and ideally, quarantined in a separate facility for a specific period, typically 2-4 weeks. During this time, the fish should be closely monitored for any signs of illness, and appropriate treatments should be administered if necessary.

Maintaining appropriate stocking densities is also crucial in reducing stress and disease susceptibility. Overcrowding can lead to poor water quality and an increased risk of disease, making fish more susceptible to infections.

Water quality management plays a significant role in maintaining fish health and preventing disease outbreaks. Regular monitoring of key water quality parameters, such as temperature, pH, dissolved oxygen, and ammonia, is essential. In Malawi, where water quality can fluctuate due to seasonal variations and agricultural runoff, maintaining optimal water quality conditions for the cultured fish species is crucial. If necessary, treating incoming water with disinfectants or using filtration systems can help remove suspended solids and organic matter. Implementing regular water exchange is also vital for maintaining water quality and eliminating waste products.

Feed management is another critical aspect of biosecurity. Using high-quality feed from reputable suppliers and storing it properly to prevent spoilage and contamination are essential. In Malawi, where feed costs can be a significant expense, farmers may be tempted to use lower-quality feeds. However, this can compromise fish health and increase the risk of disease. Proper feeding practices, such as avoiding overfeeding and promptly removing uneaten feed, are also important for maintaining water quality and preventing disease outbreaks.

Hygiene and sanitation are fundamental to biosecurity. Regularly disinfecting equipment, such as nets, buckets, and tanks, as well as disinfecting footwear and clothing before entering farm facilities, can help prevent the spread of pathogens. In Malawi, where farmers may share equipment, this is particularly important. Practising good hand hygiene, especially after handling fish or equipment, is also essential. Thoroughly cleaning and disinfecting ponds or tanks between production cycles and promptly removing dead or dying fish are also crucial.

Personnel and visitor management are essential for preventing the introduction and spread of diseases. In Malawi, training farm personnel on biosecurity protocols and disease prevention is crucial. Limiting access to farm facilities to authorised personnel only and requiring visitors to disinfect footwear and clothing can further enhance biosecurity. Establishing a system for reporting suspected disease outbreaks is also important for early detection and response.

Finally, disease surveillance and monitoring are crucial for early detection and control of disease outbreaks. In Malawi, where access to diagnostic services may be limited, regular inspections of fish for signs of disease are essential. Conducting diagnostic testing when a disease is suspected and maintaining accurate records of fish health, water quality, and disease outbreaks can further enhance disease management and control.

Fish Diseases and Impacts

Disease outbreaks pose a significant threat to aquaculture in Malawi, resulting in substantial economic losses due to increased mortality, decreased growth, and higher production costs. As recognised by the FAO (2020), diseases are a major obstacle to sustainable aquaculture development. In Malawi, where many fish farmers operate on a small scale with limited resources, the challenges of preventing and controlling diseases are particularly acute. These challenges include a lack of training in aquaculture disease management, limited access to effective and affordable drugs, the high cost of quality feed, and inadequate financial support. Addressing these issues through improved training and support systems is crucial for reducing disease outbreaks and enhancing the economic performance of fish farms.

Infectious diseases, caused by viruses, bacteria, parasites, fungi, or pests, pose a significant threat to aquaculture productivity in Malawi. These diseases can spread rapidly through the movement of infected fish, causing devastating effects on local

fish farms. In developing countries like Malawi, fish diseases hinder sustainable development goals by reducing income, leading to job losses, compromising food availability, and threatening nutrition and food security. Due to the predominantly small-scale and rural nature of aquaculture in Malawi, many infections go undetected, untreated, and unregistered, placing a heavy burden on communities striving to overcome poverty.

Fish diseases can originate from infectious organisms, such as bacteria, viruses, fungi, parasites, and protozoa, or from non-infectious causes related to environmental stressors or poor management practices.

Common Fish Diseases

Given the limited resources and diagnostic capabilities in Malawi, many farmers may struggle to identify specific pathogens. However, recognising common symptoms is crucial. Here are some key diseases and their signs, relevant to the local context:

- **Bacterial Diseases:**
    - Red Pest, Dropsy, Tail/Fin Rot, and Ulcers are common and often linked to poor water quality and stress.
    - Mycobacteriosis, associated with overcrowding, is a concern in densely stocked ponds.
    - *Aeromonas spp* infections, common in caged tilapia spp and characterised by red patches or spots on the skin, fins and internal organs with mortalities.
- **Fungal Diseases:**
    - Epizootic Ulcerative Syndrome (EUS), Fish usually develop red spots or small to large ulcerative lesions on the body. The occurrence of skin

lesions and ultimately mortality varies according to fish species. Fish presenting with lesions are usually weak and appear darker in colour.
    - Saprolegnia, indicated by cotton-like growths, often follows injuries or other infections.
    - Mouth Fungus can be fatal and is exacerbated by poor hygiene.
- **Parasitic Diseases:**
    - Argulus (fish lice), Anchor Worms, and Flukes are prevalent and can cause significant irritation and secondary infections.
    - Ich (white spot disease) is highly contagious and can lead to high mortality.
    - Protozoan Diseases: Ich, Costia, and other protozoan infections are linked to poor water conditions and stress.
- **Viral Diseases:**
    - Lymphocystis, causing white swellings, is a concern, though often not fatal.

Impacts of Fish Diseases include:

1. ***Economic Losses:*** High mortality rates and reduced growth lead to significant financial losses for farmers.
2. ***Food Security:*** Disease outbreaks threaten the availability of fish, a crucial protein source, impacting food security.
3. ***Livelihoods:*** Small-scale farmers heavily rely on aquaculture, and disease outbreaks can devastate their livelihoods.
4. ***Limited Resources:*** Access to diagnostic services and effective treatments is limited, making disease management challenging.
5. Public health risks because some diseases are zoonotic.

Recommendations for Malawi on Fish Welfare, Focusing on:

1. ***Training and Education:*** Provide farmers with training on disease recognition (passive surveillance), prevention and management.
2. ***Biosecurity Measures:*** Emphasise the importance of biosecurity practices to prevent disease introduction and spread.
3. ***Improved Water Management:*** Promote proper water quality management to reduce stress and disease susceptibility.
4. ***Access to Resources:*** Facilitate access to affordable and effective treatments and diagnostic services.
5. ***Community-Based Approaches:*** Encourage community-based disease surveillance and management.

General Treatment Options

Managing fish diseases in Malawi necessitates a comprehensive strategy tailored toward specific ailments and the resources available to farmers. Treatment approaches range from thorough disinfection of tanks and ponds using readily available agents, such as quicklime (applied cautiously and before restocking), to the application of specific remedies. While a variety of treatments, such as common salt solutions for external parasites, and in limited cases and with expert guidance, the judicious use of antibiotics for bacterial infections, may be considered, access to other listed chemicals, like malachite green, acriflavine, and copper sulphate, can be challenging. Therefore, strict adherence to correct dosages is paramount for any treatment undertaken. In situations of severe disease outbreaks or limited resources, the most practical course of action may, unfortunately, involve culling, slaughtering, or complete destruction of infected fish stocks to prevent further spread of the disease. Regardless of the chosen treatment, addressing underlying issues such as poor water quality through immediate and

significant water changes, as well as reducing overcrowding, is fundamental to successful disease management and preventing recurrence.

Important Considerations for Treatment in Malawi

- ***Antibiotic Use:***
    - Given limited access, focus on **prevention** through good water quality, proper stocking densities, and stress reduction.
    - If antibiotics are necessary (and obtained through proper channels), seek guidance from experienced aquaculture extension officers or veterinary professionals on appropriate types, dosages, and durations.
    - **Practical Application:** When using antibiotics in ponds, consider treating a smaller, contained section, if possible, to minimise impact on the entire system. Always monitor water quality closely.
    - **Policy Emphasis:** Farmers should be educated on the dangers of indiscriminate antibiotic use and the importance of following professional advice to prevent resistance.
- ***Parasite Removal:***
    - **Practical Application:** For small-scale farmers with manageable numbers of fish, demonstrate the technique of careful manual removal of larger parasites like anchor worms using clean forceps, followed by topical treatment with readily available antiseptics like diluted povidone-iodine if accessible.
- ***Chemical Safety:***
    - **Practical Application:** Emphasise the use of locally available protective gear like sturdy rubber gloves and old clothing. Demonstrate safe handling and dilution techniques in well-ventilated areas outdoors. Clearly explain the risks of exceeding recommended dosages.

    - **Education Focus:** Develop visual aids and practical demonstrations on safe chemical handling, even with limited protective equipment.
- ***Access to Treatments:***
    - **Practical Application:** Focus heavily on **preventative measures** as the primary strategy. Explore and promote the use of readily available and low-cost treatments like salt for various external parasites. Research and disseminate information on any locally sourced plant-based remedies with scientifically supported efficacy, if available and safe.
    - **Long-Term Solutions:** Advocate for improved access to essential veterinary drugs and chemicals through government programmes or farmer cooperatives, along with training on their safe and effective use.

Other Practical Approaches

- **Water Quality Management as Treatment:** Emphasise that often, the most effective "treatment" is immediate and significant improvement of water quality parameters like dissolved oxygen, ammonia, nitrite, and pH through water changes, increased aeration (using simple methods like splashing or paddle wheels if available), and reducing organic load.
- **Stress Reduction:** Educate farmers on minimising stress during handling (using soft nets, reducing handling time), transportation (using appropriate stocking densities and cooler times), and stocking (gradual acclimatisation).
- **Quarantine:** Reinforce the importance of quarantining new fish in a separate tank with good water quality and observation for several weeks, even if using basic containers. Salt can be added to quarantine tanks as a general prophylactic.
- **Pond and Tank Sanitation:** Promote regular cleaning and disinfection of ponds and tanks between stocking cycles using readily available

disinfectants like quicklime (used with caution and proper safety measures before restocking).

Non-Infectious Health Issues

In addition to infectious diseases, fish can suffer from non-infectious health problems, including:

- ***Genetic Abnormalities:*** Particularly relevant in breeding programmes, congenital issues can arise from genetic factors within the fish stock.
- ***Physical Trauma:*** Injuries are possible due to routine handling, netting during harvesting or transportation, or other forms of physical stress encountered during farm management.
- ***Digestive Issues (Constipation):*** Often linked to inadequate fibre or imbalances within the provided feed.
- ***Nutritional Deficiencies:*** Providing insufficient or poorly balanced diets can lead to a range of health problems, impacting growth, immunity, and overall well-being.

Disease Reporting

Maintaining accurate records of diseases, treatments, transportation, mortality rates, and causes of mortality is essential for monitoring fish health and welfare in Malawi. All fish farms, regardless of size, should keep these records and use them to improve their management practices.

As a precautionary measure, any suspected serious disease or unusual mortality event should be reported to the relevant authorities, such as the Department of Veterinary Services or the Fisheries Department, even if the specific disease is unknown. This is vital for early detection and control of disease outbreaks, protecting both individual farms and the broader aquaculture sector.

Antimicrobial Resistance (AMR) and its Spread

Antimicrobial resistance (AMR), where pathogens develop the ability to survive medications intended to kill them, poses an increasing risk to both public health and the developing aquaculture sector in Malawi. While comprehensive data specifically on AMR in Malawian fish farming is still emerging, the high burden of AMR reported in the human health sector, with over 15,000 annual deaths linked to this issue, signals a significant underlying problem. The misuse and overuse of antibiotics, antifungals, and antiparasitic drugs in human health, as well as potentially in livestock that contributes manure to fish ponds, are key drivers. In Malawian aquaculture, the challenge is compounded by limited diagnostic capabilities, which hinder the accurate identification of fish diseases and often lead to empirical and potentially inappropriate use of antimicrobials. This lack of targeted treatment, coupled with insufficient awareness of antimicrobial stewardship practices among fish farmers, creates an environment conducive to the further development and spread of AMR within the aquatic ecosystem and potentially beyond.

Antibiotics are often administered to fish through feed, baths, or injections, potentially leading to the accumulation of antibiotic residues in fish and the aquatic environment (Chowdury *et. al.,* 2022). If proper withdrawal periods are not observed, consumers may ingest these residues, contributing to AMR development and posing other health risks. Furthermore, poor animal welfare and biosecurity practices can increase the risk of infections, leading to a greater reliance on antibiotics.

How AMR Spreads from Animals (Including Fish) to Humans

The spread of resistant bacteria from animals, including fish, to humans in Malawi can occur through several pathways:

- ***Contamination of Food:***
    - Poor antimicrobial stewardship in aquaculture can lead to antibiotic residues and resistant bacteria contaminating fish products.
    - Improper handling and processing of fish can further spread these contaminants.
- ***Occupational Exposure:***
    - Fish farmers, fish processors, and individuals involved in fish handling are at risk of direct exposure to resistant bacteria.
    - This is particularly relevant in Malawi, where many people are involved in small-scale aquaculture and fish processing.
- ***Environmental Transfer:***
    - Resistant bacteria, resistance genes, and antibiotic residues can spread through water sources, contaminating rivers, lakes, and ponds.
    - In Malawi, where many communities rely on surface water for drinking and other purposes, this poses a significant risk.
    - The use of fish pond water for irrigation can also spread resistance genes to crops, and then to humans.
- ***Recreational Activities:***
    - Fishing and swimming in contaminated water bodies can expose individuals to resistant bacteria.
    - This is important to note in Malawi, due to the reliance on Lake Malawi and other bodies of water for recreation and daily activities.

Addressing AMR in Malawi

Antimicrobial resistance (AMR) poses a critical threat to human, animal, and environmental health, making it essential to address it in both fish and humans. Humans can contract AMR bacteria from contaminated fish or aquaculture, reducing antibiotic effectiveness and increasing the severity of infections; while in aquaculture, AMR causes disease outbreaks, impacting food security and

livelihoods, and leading to increased antibiotic use, which further spreads resistance. Additionally, aquaculture wastewater can spread AMR bacteria and residues into the wider environment. A One Health approach is therefore crucial, recognising the interconnectedness of health across species and the environment, to protect public health, ensure food security, and preserve the effectiveness of antimicrobials. To mitigate the risks of AMR in Malawi, it is crucial to:

- Promote responsible antimicrobial use in aquaculture, plant and human health through a One Health approach.
- Strengthen diagnostic capacity to ensure appropriate treatments.
- Enhance surveillance and monitoring of AMR.
- Raise public awareness about the risks of AMR.
- Improve biosecurity practices in fish farms.
- Explore alternative disease prevention and treatment methods.
- Improve sanitation and water treatment.

Impact of AMR

Antibiotics, including oxytetracycline, amoxicillin, and sulphadiazine-trimethoprim, are used in Malawian aquaculture to treat or prevent fish diseases, aiming to maximise productivity. However, the misuse and overuse of these drugs lead to antimicrobial resistance (AMR), resulting in treatment failures and negatively impacting fish production and welfare (Schar et *al*., 2020). In Malawi, where many fish farmers rely on small-scale operations, treatment failures due to AMR can have devastating economic consequences.

Furthermore, the inappropriate use of antimicrobials in aquaculture results in environmental contamination with antimicrobial residues through water distribution systems (Schar et *al*., 2020). In Malawi, where many communities rely on surface water sources, this poses a significant risk to both human and environmental health. These residues can disrupt the environment's microbiome, affecting ecosystem

functions. Aquaculture systems with high antimicrobial use can also serve as reservoirs for antimicrobial resistance genes, facilitating AMR development in animals and humans. Given the limited availability of authorised antibiotics for aquaculture species globally, it is crucial to preserve their effectiveness.

Combatting AMR (Malawi Context)

To address the growing threat of AMR in Malawi, aquaculture farmers can contribute to prevention and control while meeting the increasing demand for seafood. The FAO action plan on AMR recommends prudent antimicrobial use and effective biosecurity practices. Key recommendations for Malawi include:

1. ***Prudent and Responsible Use of Antimicrobials:***
    - Educate farmers on the importance of using antimicrobials only when necessary and under the guidance of qualified professionals when possible.
    - Promote the use of appropriate dosages and treatment durations.
2. ***Provision of Clean, Safe, and Disease-Free Aquatic Systems:***
    - Emphasise the importance of good water quality management and biosecurity practices to prevent disease outbreaks.
    - Promote the use of proper pond hygiene and sanitation.
3. ***Proper Routine Monitoring of Resistance During Disease Outbreaks:***
    - Encourage farmers to report suspected treatment failures and to seek professional advice.
    - When possible, collaborate with research institutions to monitor AMR trends.
4. ***Proper Animal Welfare Standards:***
    - Educate farmers on the importance of reducing stress in fish through proper handling, stocking densities, and environmental conditions.
    - Stress reduction leads to stronger immune systems.

5. ***Routine Removal of Antibiotic Residues in Water:***
    - Explore and promote the use of affordable and effective water treatment methods, such as filtration and sedimentation.
    - Natural methods, such as allowing ponds to rest, should also be promoted.
6. ***Vaccination of Aquatic Food Animals:***
    - Promote the use of available fish vaccines, particularly for common diseases.
    - Work with research institutions to develop and distribute vaccines suitable for local fish species.
7. ***Probiotics:***
    - Educate farmers on the benefits of using probiotics to enhance fish health and immunity in aquaculture (Chabrillon *et. al.*, 2005).
    - Promote the use of locally available and affordable probiotic products.
8. ***Immunostimulants:***
    - Explore and promote the use of immunostimulants, such as β-1,3 glucans, to enhance fish resistance to diseases (Ngamkala *et. al.,* 2010).
    - Research local sources of immunostimulants.
9. ***Broad-Host Range Phages:***
    - While phage therapy may be less accessible, explore opportunities for research and development in this area.
10. ***Traditional Medicinal Plants:***
    - Encourage research and documentation of traditional medicinal plants with antimicrobial properties (Newaj-Fyzul and Austin, 2015).
    - Promote the safe and effective use of these plants in aquaculture.

Conclusion

To combat AMR in Malawi, fish farmers must implement antimicrobial stewardship practices, encompassing good animal health practices and biosecurity measures with government support. Proper antimicrobial use, according to prescriptions, is essential to maintain their effectiveness. Furthermore, adherence to withdrawal periods before harvesting and selling fish is crucial to prevent the presence of antimicrobial residues in food products. Collaboration between farmers, researchers, and government agencies is essential to address the complex challenges of AMR in Malawi.

Q&A Session

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

Discussion Points

- Do you have any biosecurity protocols or systems on your farm?
- Have you experienced any disease outbreaks on your fish farm before? If you have, share your experience on how you discovered the onset of the disease (e.g. what were the signs), if and how you diagnosed the cause of the disease, and what you did to treat the disease and combat the spread.

- Do you engage qualified professional(s) to provide diagnostic and treatment services for your fish farm? If you don't, why? What are the alternative options you employ?
- Discuss your current use of antibiotics. Do you consider it currently as antimicrobial stewardship or misuse?
- Do you have a record-keeping system for your fish health, disease reports and antibiotic use?

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