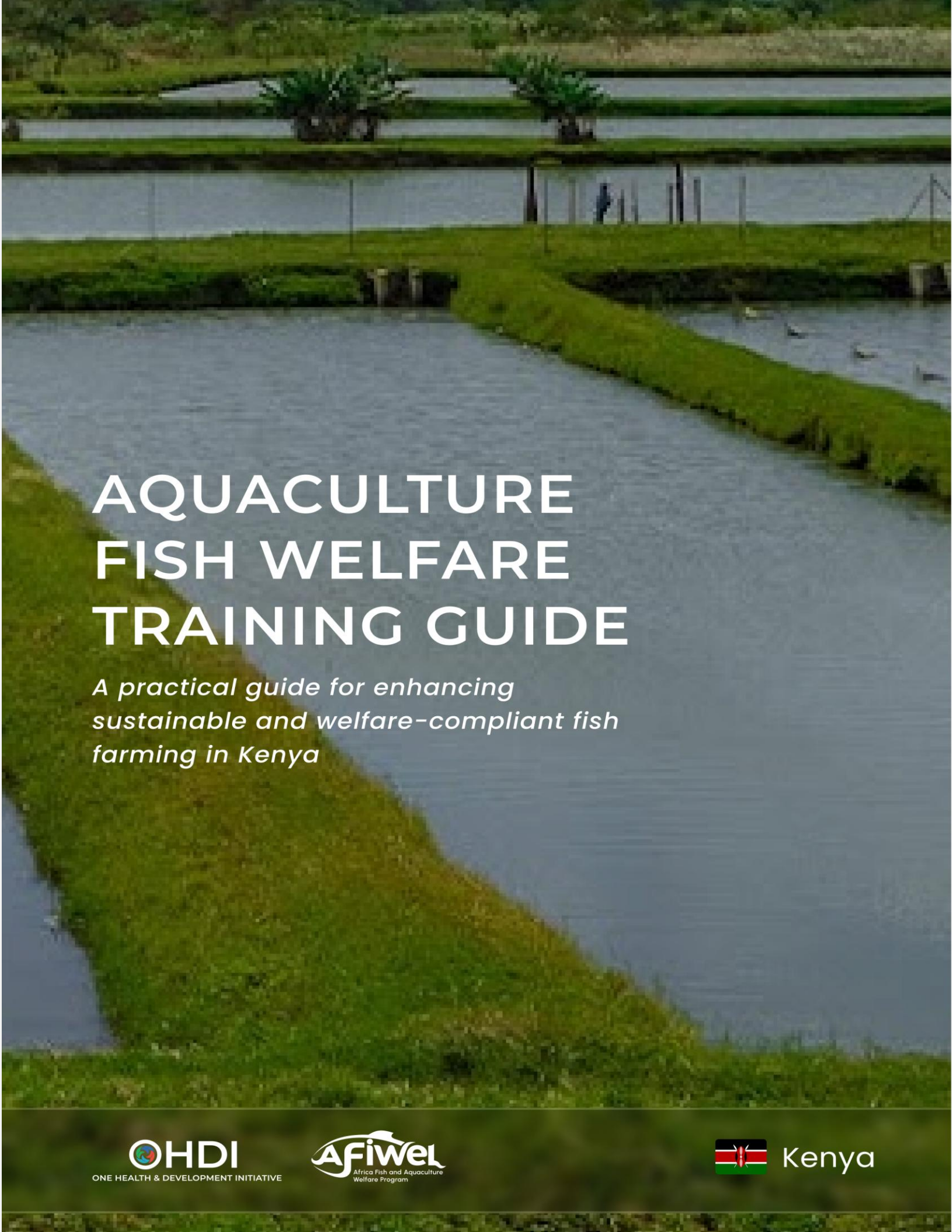

AQUACULTURE FISH WELFARE TRAINING GUIDE

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

OHDI
ONE HEALTH & DEVELOPMENT INITIATIVE

AFIWEL
Africa Fish and Aquaculture Welfare Program

Kenya

CONTRIBUTIONS AND ACKNOWLEDGEMENTS

Writing and development

Job Omweno (BSc, MSc) – Africa Fish Welfare (AFIWEL) Fellow, OHDI

Technical Review and Validation

- Prof. Andrew Wamalwa Yasindi, Department of Biological Sciences, Egerton University, Kenya.
- Edwin Muga, County Director of Fisheries, County Government of Kisii, Kenya.
- Mr Kobingi Nyakeya, Senior Research Scientist, Kenya Marine and Fisheries Research Institute (KMFRI), Baringo Station, Kenya.
- Dr Zipporah Gichana, Chair, Department of Environment, Natural Resources and Aquatic Sciences, Kisii University, Kenya.
- Dr Paul Sagwe Orina, Assistant Director (Aquaculture) and Centre Director, Kegati Aquaculture Centre, KMFRI, Kenya.
- Dr Stephen Opiyo, Postdoctoral Fellow, Unit for Environmental Sciences and Management (UESM), Faculty of Natural and Agricultural Sciences, North-West University, South Africa.
- Ms Mercy Chepkirui, Project Manager/Aquaculture Specialist, Rio Fish Ltd., Kenya.
- Dr Christopher M. Aura, Director, Freshwater Systems Research, Kenya Marine and Fisheries Research Institute (KMFRI), Kisumu, Kenya.
- Dr Kikiope Oluwarore, Founder and Executive Director, One Health Development Initiative (OHDI)

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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 a 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 Kenya, 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: 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 Kenya and across Africa.

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

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MODULE 1: OVERVIEW OF AQUACULTURE IN KENYA

Definition and scope of aquaculture

What is aquaculture?

Aquaculture is defined as the farming (propagation from spawn, seed, eggs, or spat and rearing) of aquatic organisms, including finfish, shellfish (such as molluscs and crustaceans), and aquatic plants in controlled or semi-controlled environments, mainly for commercial, recreational, and conservation purposes. The sector requires varying levels of farm management activities to increase yield, such as stocking and daily husbandry, including feeding, protection from predators, monitoring water quality, growth performance and ensuring good health and welfare.

Why is aquaculture important regionally and globally?

According to the latest estimates, aquaculture experienced an average annual growth rate of 8.8%, contributing 3.3% to total fish production, which accounted for approximately 17% of the total animal protein intake worldwide (FAO, 2018). This growth is driven by the increasing demand for affordable, high-quality animal protein to promote food and nutrition security, as well as the decline of wild fisheries due to climate change, overexploitation, and other factors (FAO, IFAD, and WFP, 2015). Aquaculture is also a significant contributor to global economic growth and job creation. As the demand for fish rises, the sector provides a sustainable means of producing fish while simultaneously generating millions of jobs across its value chain.

Aquaculture offers direct jobs to millions globally, ranging from fish farming and feed manufacturing to processing, distribution, and retailing. This is particularly important in communities where aquaculture serves as a primary or secondary source of income (reference here), significantly improving livelihoods and promoting local economic development (FAO, 2022). The sector is a critical path

to financial stability for small-scale fish farmers, allowing them to support their families and improve their living standards (FAO, 2022). The sector also fosters investment in supporting industries, including transportation, equipment manufacturing, and feed production, creating a ripple effect across multiple sectors. Countries that have embraced aquaculture have seen increased trade and exports and strengthened their economies (OECD, 2020).

Kenyan context

Kenya's aquaculture sector has experienced significant growth, contributing to food security and socio-economic development. Advancements were achieved when the government made a notable move to fund aquaculture activities in approximately 140 constituencies across the country under the "Economic Stimulus Package" in 2008. Under the Kenya Vision 2030, the sector is identified as one of the key areas that can stimulate economic development, hence its continuous growth. Equally, subsequent governments since 2013 have recognised the fisheries sector as a significant component of the Blue Economy Concept (BEC) that can enhance the socio-economic well-being of the general public. Therefore, more budget allocation to boost aquaculture has been realised. In 2022, the country's total fish production reached approximately 174,000 metric tons, with aquaculture accounting for about 12.7% of this output (Munguti *et al*, 2023).

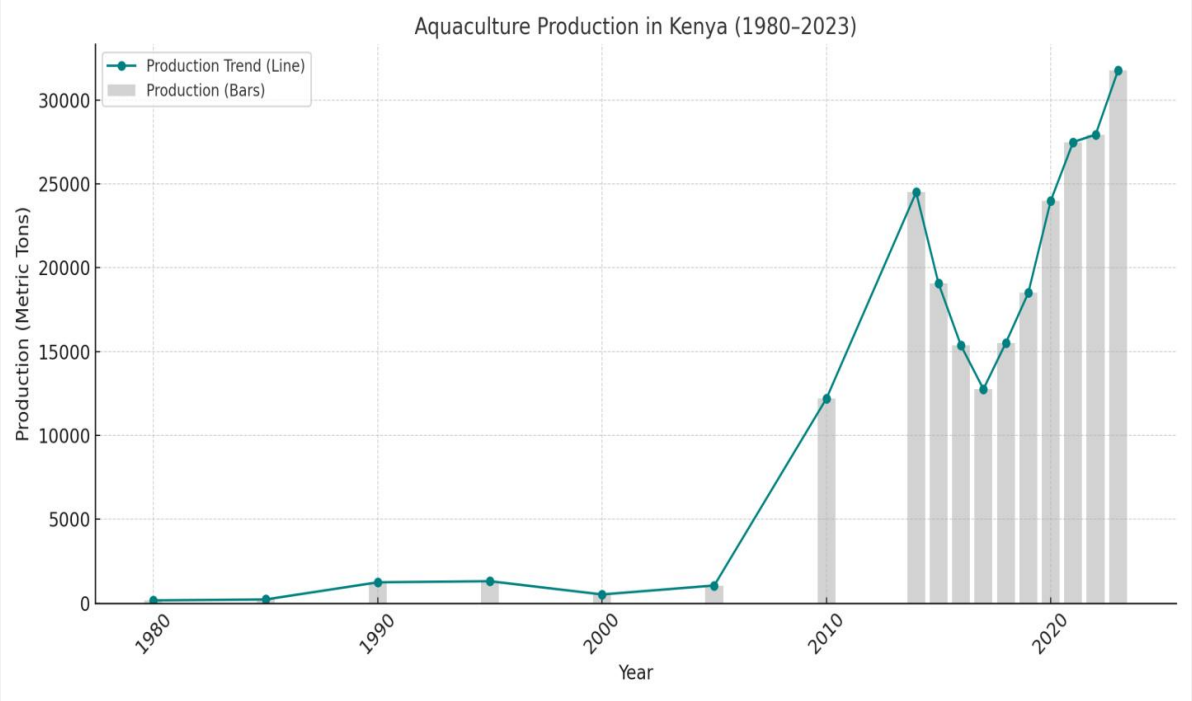

Figure 1 Trends in aquaculture production in Kenya 1980 - 2023 (Data from KNBS Annual statistical bulletins)

Types of aquaculture in Kenya

Kenyan aquaculture comprises both freshwater and marine (mariculture) systems:

Freshwater aquaculture: Dominates the sector, contributing to 80% of the country's total aquaculture production. Warm water species such as Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and Common carp (*Cyprinus carpio*) are commonly farmed in inland ponds and cages, while the Rainbow trout (*Oncorhynchus mykiss*) is farmed in cold, high-altitude regions of Mount Kenya.

Mariculture: Involves the cultivation of marine species like seaweed, finfish such as Milkfish (*Chanos chanos)* and Grey mullets (*Mugil cephalus*), as well as shellfish including Mud crabs (*Scylla serrata*), Oysters (*Saccosteria cucullata*), and shrimp (*Penaeus monodon*) (Ogello *et al.*, 2013). In 2022, seaweed farming produced nearly 100 tons, valued at over $30,000, providing alternative livelihoods amid climate challenges.

Challenges facing the aquaculture sector in Kenya

The aquaculture industry in Kenya, despite its growth, faces significant challenges that hinder production, including limited access to affordable, high-quality feed, which constitutes 65-70% of operational costs, and inaccessible loan facilities due to high interest rates. Additionally, high taxes and energy costs reduce farmers' purchasing power, while insufficient infrastructure, such as cooling plants and rural roads, limits operational efficiency (Munguti *et al.*, 2014). Regulatory issues, including overlapping institutional roles and inadequate law enforcement, exacerbate these challenges, alongside environmental degradation from cage culture and the impacts of climate change. Furthermore, the lack of quality fingerlings and inadequate dissemination of scientific information hinder the adoption of sustainable practices (Prah *et al.*, 2024). Addressing these multifaceted issues is crucial for the industry's sustainable development.

Recent developments and initiatives to boost aquaculture in Kenya

To address the existing challenges, innovative practices and sustainable resource management are being explored. These include:

i. The introduction of the Affordable Recirculation Aquaculture System (A-RAS), which has been piloted in Nyeri County, offering a sustainable solution for the recycling of wastewater. A-RAS has demonstrated quadrupled productivity compared to traditional ponds (Agroberichten Buitenland, 2025).
ii. Workshops and collaborations to promote integrated multi-trophic aquaculture (IMTA) among Kenyan aquaculture stakeholders.
iii. Exploring alternative aqua-feed sources, such as the use of black soldier fly larvae, *Azolla*, *Duckweed* and microalgae to reduce dependence on traditional fishmeal, offering a cost-effective and sustainable alternative.
iv. Government gazettement of spatial planning maps for Lake Victoria, which will pave the way for more cage deployment in the lake.

v. Government and donor funds to women and youths engaging in aquaculture ventures.
vi. Introduction of cost-effective production strategies to boost aquaculture activities in the country, such as Climate Smart Aquaculture, Aquaculture Business Development Enterprise, etc.

Aquaculture production systems

Kenya's aquaculture systems are primarily composed of extensive and semi-intensive systems, with rare instances of intensive systems.

Extensive systems

These are low-input, low-output production systems that involve the culture of low-value omnivorous fish, such as Nile tilapia (*Oreochromis niloticus*), Common carp (*Cyprinus carpio*), and African catfish (*Clarias gariepinus*), at low stocking densities of less than 3 fish per m^2. Fish are stocked in still-water earthen ponds, rice fields, small water bodies, and other impoundments, often with little or no supplementary feeding, as the fish are allowed to forage for themselves and mostly rely on natural pond productivity. This system is utilised by the majority of small-scale rural farmers and contributes to about 10% of the farmed fish in Kenya, and is characterised by low production ranging between 500 and 1,500 Kg/Ha/year (Ngugi *et al.*, 2007).

Semi-intensive systems

These systems form a bulk of aquaculture production in Kenya, practised by over 90% of fish farmers (FAO, 2016). The system uses earthen, liner and concrete ponds, and cages to cultivate *O. niloticus* and *C. gariepinus*, either in monoculture or polyculture, often depending on pond fertilisation and supplementary feeding (Munguti *et al.*, 2014). Commercial production in these systems ranges between 1 and 6 Kg/m2/year or 1,000 and 2,500 Kg/Ha/year, depending on the management levels employed by individual farmers (Ngugi *et al.*, 2007).

Intensive systems

These are highly industrialised production systems in which water flows in and out continuously, allowing higher stocking densities of up to 250 fish per m^3 (Njiru *et al.*, 2018). These systems are *characterise*d by high fish production per unit area e.g.,10,000 and 80,000 Kg/Ha/year of *O. mykiss* produced from raceways are concentrated in the Mount Kenya region (FAO, 2016), while 12 million kg of the *O. niloticus* has been produced from floating cages in Lake Victoria per production cycle of eight months (Njiru *et al.*, 2018). They also include Recirculating Aquaculture Systems (RAS) production in the outskirts of Thika and Machakos town (such as Kamuthanga Farm and Thika Greens). Due to the high initial capital investment, high management requirements, and high-quality feed requirements for complete feeding, the system is only practised by 3% of farmers.

Q&A session

In a facilitator-led training session, the fish welfare trainers or facilitators should provide opportunities for trainees to ask questions and engage in discussions about the module. The facilitator should provide clear and comprehensive answers to foster a collaborative and interactive learning environment.

If you are reading this training manual independently, you can share your questions in the following ways to receive answers and further support, where necessary:

Email Support: Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org

Discussion forum

Share your questions on the discussion forum on the face-to-face or online training platform for Fish Welfare. To make the most out of this training guide, it is essential to understand the backgrounds and motivations of the participants:

Introduction of the participants: Farmers: Describe your fish farm, including the type of farming system (intensive, extensive, semi-intensive), culture system,

species of fish, number of fish, location, successes, and challenges. Non-farmers discuss why you are taking the course and what you hope to benefit from it. Discuss the most common fish farming systems practised in your area and why these systems are prevalent. This discussion can provide valuable insights into local practices and preferences. Share which fish farming system you prefer the most and why. Include your personal experiences (if any) with your preferred fish farming system, highlighting the advantages and disadvantages.

Integrated aquaculture practices: Discuss whether you have practised integrated aquaculture before. If yes, share details about the integrated fish farm system, your experience with it, and what you consider the advantages and disadvantages of the system.

MODULE 2: INTRODUCTION TO ANIMAL WELFARE

This module introduces and provides an overview of the general principles and rationale of animal welfare. It introduces the five freedoms and the five domains of animal welfare, and offers insights into common animal welfare violations and practices, with a particular focus on fish. Additionally, it provides an overview of country-level, policy, legal, and institutional frameworks related to animal welfare.

Overview, history, and trends of animal welfare

Animal welfare denotes the positive well-being of animals, which also influences socio-economic and environmental benefits derived from animals. Although previously marginalised, animal welfare has advanced remarkably over the years due to the growing recognition of the connection between animal sentience and their well-being. Initially centred on health disposition, disease detection and animal management (Pinillos *et al.*, 2016), the field has evolved to include a better understanding of animals' social *behaviours*, cognitive abilities, and their capacity to experience pain, suffering and psychological stress (Kumar *et al*., 2019).

Evolution of animal welfare

The evolution of animal welfare has progressed through distinct historical phases. In ancient civilisations (prehistoric times – 600 BCE), attitudes toward animals varied, with some societies like the Egyptians and Greeks showing reverence and implementing protective laws. Between 600 BCE and 1800 CE, religious teachings such as those in Judaism and Hinduism promoted compassion for animals, while philosophers like Pythagoras and Saint Francis of Assisi advocated for their ethical treatment. The industrial revolution in the 1800s heightened concerns about animal cruelty, prompting figures like Richard Martin and William Wilberforce to champion animal welfare laws. This led to the formation of dedicated organisations such as the Royal Society for the Prevention of Cruelty to Animals (RSPCA) in 1824. By the 20th century, growing concerns over the treatment of

laboratory animals led to the development of regulatory frameworks to protect animals in scientific research.

The late 20th century to the present has seen further expansion in animal welfare concerns, addressing issues such as factory farming, wildlife conservation, and animal entertainment, with NGOs playing a key role in advocacy. Despite these advancements, poor animal welfare practices persist due to factors such as limited awareness, inadequate resources, and weak policies. The integration of animal welfare into the 'One Welfare' concept now emphasises interdisciplinary collaboration to enhance animal, human, and environmental well-being (Marchant-Forde and Boyle, 2020).

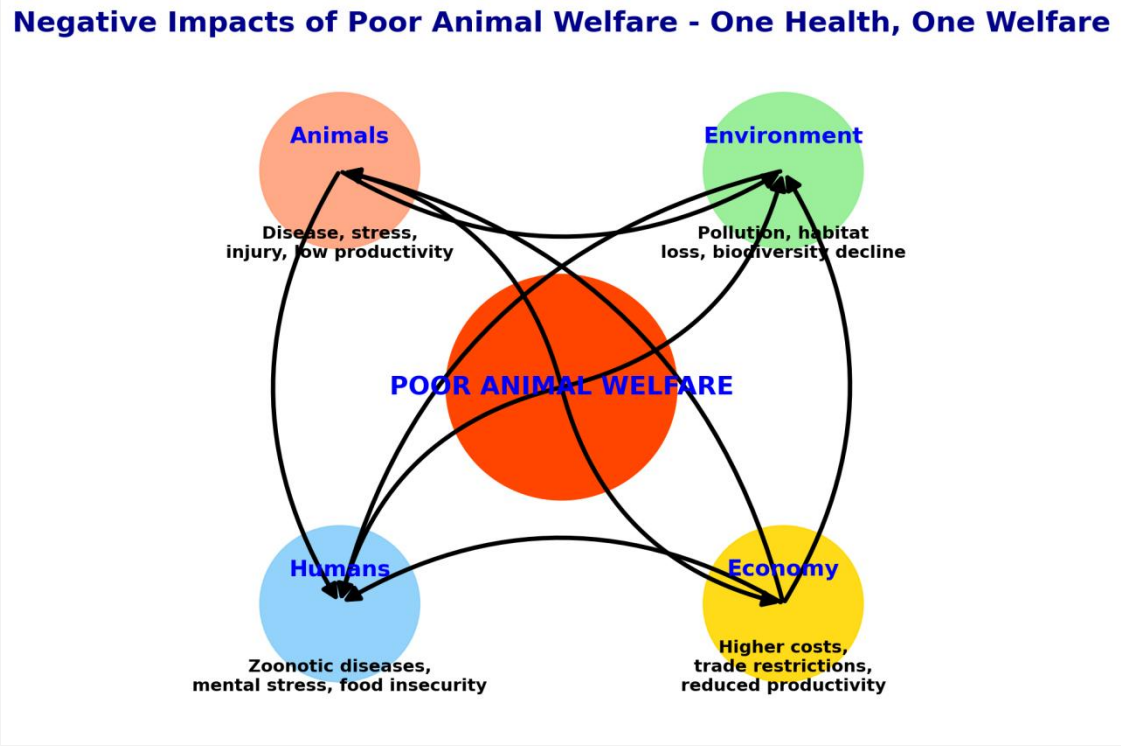

Figure 2 Negative impacts of poor animal welfare using the One Health One Welfare concept (Source: Author, 2025)

The Five Freedoms of Animal Welfare

The "Five Freedoms of Animal Welfare" are essential guidelines for ensuring good animal welfare practices globally, as validated by organisations such as the World

Organisation for Animal Health (WOAH) (Mellor, 2016). Improved fish welfare can reduce the transmission of diseases and zoonotic infections (Madzingira, 2018). Enhanced practices boost production by lowering mortality, increasing growth rates, and improving feed efficiency. Positive human-animal interactions foster human health and social well-being, while better welfare practices enhance food safety and meat quality (Animal Welfare Institute, 2018). Addressing housing and management concerns can improve animal health, reduce environmental footprints, and enhance economic and social performance (OHDI, 2023). Introduced by the UK's Farm Animal Welfare Council in the 1970s, the "Five Freedoms" outline key welfare objectives. The five freedoms are:

1. Freedom from hunger and thirst: Involves providing adequate food and water in a timely, consistent, balanced, and nutritious manner, free from contaminants and disease-causing organisms.

2. Freedom from discomfort: This entails ensuring a comfortable environment with healthy, high-quality water ecosystems, free from restrictions, unpleasant conditions, and harsh environmental factors such as extreme weather, noise, or other stressful situations.

3. Freedom from pain, injury and disease: This means offering adequate care and environmental conditions that prevent any form of pain or injury. It includes providing standard fish management practices, biosecurity measures, prompt and quality veterinary care, and good antimicrobial stewardship.

4. Freedom to express normal and natural behaviour: This involves creating conditions that are not overly restrictive, allowing fish to move freely (including swimming and other forms of locomotion), vocalise, feed, and interact with other fish. The environment should mimic natural settings as closely as possible to enable the expression of natural instincts and *behaviours*.

5. Freedom from fear and distress: This includes treating fish humanely to prevent fear, anxiety, distress, or other forms of psychological suffering.

Though designed for terrestrial animals, this framework applies partially to fish. Since achieving a stress-free environment is impractical, the concept of allostasis becomes relevant. Allostasis emphasises the need for controlled biological challenges that enable fish to adapt, promoting stability and improved well-being. To apply the "Five Freedoms" to aquaculture, fish must be provided with environments that balance protection from excessive stress with sufficient stimulation for natural *behaviour* and adaptation.

The five domains of animal welfare

The Five Domains of Animal Welfare provide a comprehensive, scientifically grounded framework for assessing and improving animal welfare, emphasising both physical well-being and mental states. Unlike the Five Freedoms, which primarily focus on preventing negative experiences, the Five Domains — Nutrition, Environment, Health, Behaviour, and Mental Domain describe or explain how physical conditions influence an animal's emotional state (Mellor *et al.*, 2020). The first four domains address tangible aspects such as food, shelter, and health, which collectively contribute to the fifth domain, the mental state, reflecting the animal's overall well-being (Mellor and Beausoleil, 2015).

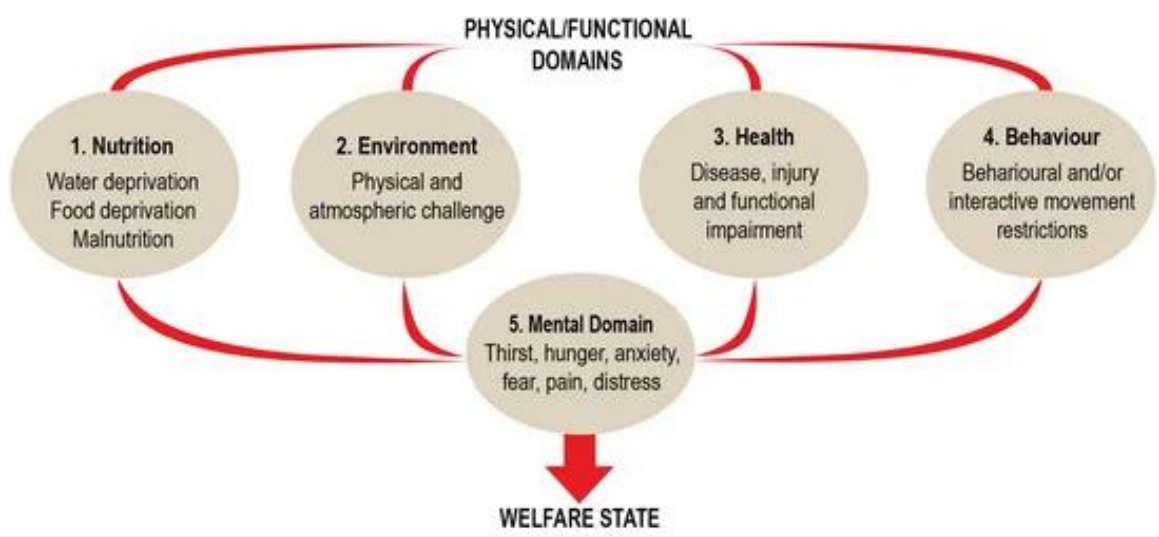

Figure 3 The five domains of animal welfare (Adapted from Mellor et al., 2020)

This model acknowledges that animals can experience a range of emotions, from negative states like pain and stress to positive ones such as comfort and contentment (Mellor *et al.*, 2020). By promoting positive experiences alongside preventing harm, the Five Domains framework aligns with modern approaches that prioritise an animal's quality of life (Webb *et al.*, 2019). The framework has gained global acceptance, especially in evaluating farm animal welfare, research practices, and pest control methods (Mellor *et al.*, 2020). Organisations like the RSPCA advocate for the Five Domains as a tool to ensure animals experience not only minimal suffering but also rewarding and satisfying experiences.

While the Five Freedoms remain essential for establishing baseline welfare standards, the Five Domains offer a more comprehensive approach by integrating both emotional and physical needs (Green and Mellor, 2011). Institutions like the Zoo Aquarium combine both frameworks, using the Five Freedoms to prevent harm and the Five Domains to actively enhance the mental well-being of animals. This integrated approach reflects a shift from simply minimising suffering to fostering positive welfare outcomes (Mellor *et al.*, 2020).

Key animal welfare violations in Kenya

In Kenya, violations of animal welfare standards frequently occur across various sectors, including livestock, aquaculture, and pet care. These violations often breach the Five Freedoms of animal welfare and include:

1. Inhumane transport: Overcrowding, exposure to extreme weather conditions, and poor water quality during fish and animal transportation result in severe stress and health risks.

2. Inhumane slaughter: Painful and distressing slaughter methods, including improper stunning techniques, compromise animal welfare.

3. Inhumane handling and mutilation: Practices such as eye-stalk ablation in female shrimp and abdominal incisions in male fish for milt extraction are often performed without anaesthesia, causing intense pain and distress.

4. Cruel training practices: Bulls, dogs, and horses used for sports, security, and farm work often endure harsh and inhumane training methods.

5. Confinement in intensive systems: Zero grazing and cage farming restrict movement and natural *behaviour*s, negatively impacting animal welfare.

6. Lack of proper veterinary care: Limited access to qualified veterinary services leads to poor disease diagnosis and treatment, compromising animal health.

7. Antimicrobial misuse: Unregulated use of antibiotics due to self-medication, substandard veterinary care, and unethical practices contributes to antimicrobial resistance.

8. Growth hormone administration: Growth hormones can cause anatomical and physiological issues, leading to discomfort and pain.

9. Inadequate provision of food and water: Prolonged fasting periods or intentional food and water withdrawal for manipulative purposes harm animal health.

10. Feed restriction in aquaculture: Extended feed deprivation during fish conditioning, grading, transport, and slaughter results in stress, injuries, and welfare concerns.

11. Harmful research conditions: Conducting research without adequate welfare considerations exposes fish to harmful and stressful conditions.

These animal welfare violations can be addressed through enhanced training *programmes*, improved regulations, the establishment of dedicated laboratories, and stakeholder engagement. Furthermore, strengthening the enforcement of welfare legislation and guidelines, such as those in fish transportation protocols, is crucial to ensuring sustainable improvements.

Kenya animal welfare legislation

Kenya has established a strong legal and policy framework to promote animal welfare, aligning with international standards. Chapter 5, section 69 of the Constitution of Kenya (2010) recognises the importance of biodiversity conservation and genetic resource protection, implicitly supporting animal welfare by acknowledging animal sentience (Republic of Kenya, 2010). The constitution highlights the shared governance in animal welfare management, whereby the national government is responsible for the protection of wild animals, while county governments oversee the welfare of domestic animals.

The Prevention of Cruelty to Animals Act (Republic of Kenya, 1962) remains the primary legislation on animal welfare, defining and penalising acts of cruelty such as beating, neglect, and overloading. While it does not explicitly define animals as sentient, it acknowledges their capacity to experience suffering. Complementing this, sections 7, 17 and 20 of the Animal Welfare and Protection Bill (2019) strengthen protections by recognising animal sentience and setting standards for farm animal care, humane transport, and ethical slaughter. The Prevention of Cruelty to Animals (Transport of Animals) Regulations (1984) ensure humane transport, while the Regulations mandate regular inspections of farm facilities and slaughterhouses. Kenya's legal framework also includes the Animal Diseases Act (1965, amended in 2012), which primarily focuses on disease control but lacks explicit provisions for animal welfare. Similarly, the Veterinary Surgeon and Veterinary Para-professionals Act (2011) provides ethical guidelines but does not directly address farming practices.

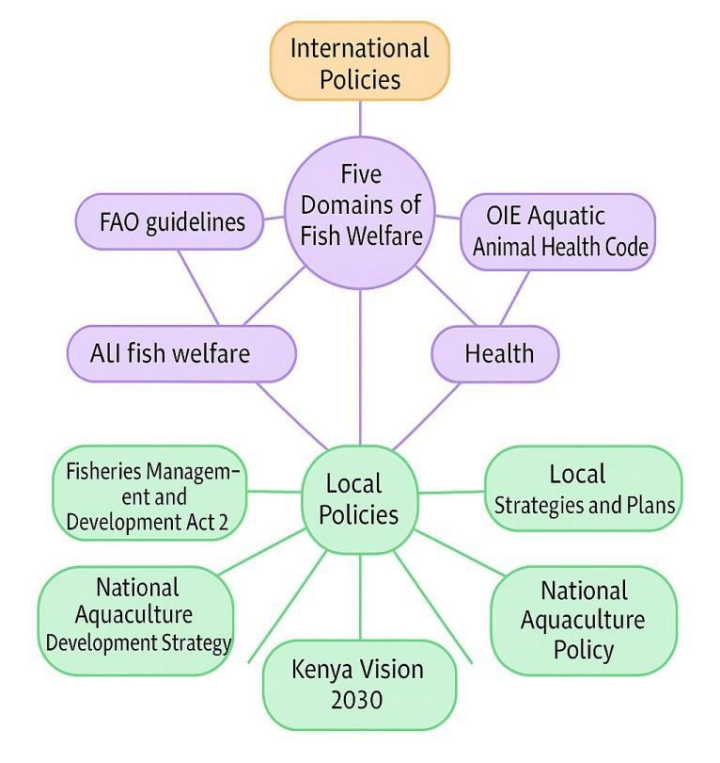

Figure 4 The Five Freedoms of animal welfare

Note: *The Five Freedoms of animal welfare serve as a central framework linking global guidelines such as FAO recommendations, the OIE Aquatic Animal Health code, the ALI fish welfare standards to Kenya's national policies and legislation, including the Fisheries Management and Development Act (2016), the National Aquaculture Development Strategy and the Kenya Vision 2030 derived from the global Sustainable Development Goals (SDGs). There is a need to strengthen regulatory frameworks to ensure comprehensive protection for fish welfare.*

Beyond legislation, Kenya has developed policies to enhance animal welfare. The Kenya Veterinary Policy (Ministry of Agriculture, Livestock and Fisheries, 2015) and the National Livestock Policy (2019) define animal welfare in terms of health, comfort, nourishment, and freedom from suffering. The Kenya National Animal Welfare Strategy and Action Plan (2017-2022) focuses on education, research, and policy development to improve compliance and awareness. Despite these

measures, enforcement remains weak, with animal welfare often overlooked in housing, transportation, and cultural practices. Overall, Kenya's recognition of animal welfare as essential to animal health, production, and trade is evident in its legal and policy frameworks. However, strengthening enforcement mechanisms and increasing awareness of the Five Freedoms would further enhance the humane treatment of animals across various sectors.

Legal, policy and institutional frameworks for fish welfare in Kenya

Kenya's fish welfare framework is anchored in key legislative instruments, notably the Fisheries Management and Development Act, 2016, and its associated regulations. These provide comprehensive guidance on the sustainable use,

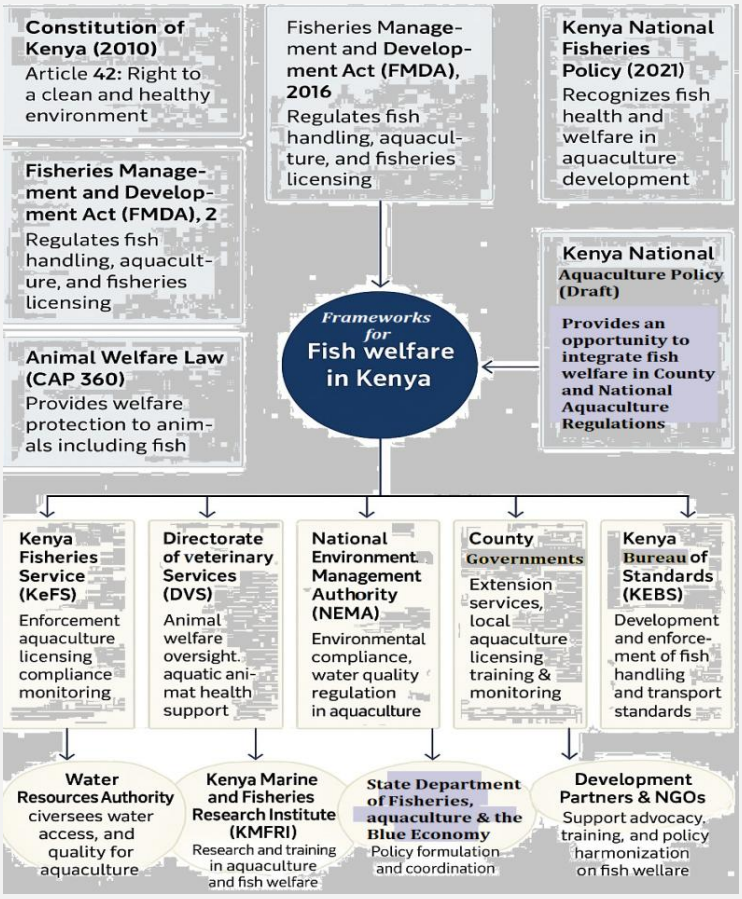

Figure 5 Frameworks for fish welfare in Kenya

protection, conservation, and management of aquaculture resources across private, public, and community lands (Biochem Team, 2022; Gatimu, 2022).

Fisheries Management and Development Act (2016)

The Fisheries Management and Development Act (2016) outlines various measures that maintain fish welfare standards. It assigns the Kenya Fisheries Service (KeFS) the responsibility of overseeing aquaculture activities and ensuring compliance with national and international standards (Opiyo *et al.*, 2023). Key welfare-related provisions include:

- **Section 65(3):** Empowers County governments to manage fish disease outbreaks through measures such as culling infected fish. The effectiveness depends on county-level capacity (Gatimu, 2022).
- **Section 66(b & c):** Regulates the introduction of exotic and genetically modified species to prevent ecological harm. However, enforcement gaps persist due to unclear guidelines (Kamau, 2020).
- **Section 70(1):** Prohibits the use of chemicals and antibiotics in aquaculture without KeFS approval, helping mitigate antimicrobial misuse, but bureaucratic delays may hinder prompt treatment (Mwainge *et al.*, 2021).
- **Section 74(2)(e):** Emphasises proactive disease surveillance, requiring enhanced resources and skilled personnel for effective implementation (Opiyo *et al.*, 2023).

Fisheries Management and Development (Aquaculture) Regulations

The Fisheries Management and Development (Aquaculture) Regulations, issued as Legal Notice No. 62 of 2024 and No. 126 of 2024, provide additional guidance for implementing the Fisheries Act. These regulations emphasise three key areas:

- Integration of aquaculture resource management at national, county, and community levels.
- Protection of aquaculture habitat diversity and species conservation.
- Community-based participatory conservation frameworks to promote sustainable practices (Biochem Team, 2022; Gatimu, 2022).

The regulations also address pollution control, overexploitation, and invasive species management, ensuring healthy aquatic ecosystems that support fish welfare (Mwainge *et al.*, 2021).

Authority and compliance of aquaculture regulations

The regulatory framework empowers the Director-General of the Kenya Fisheries Service (KeFS) to establish measures and issue notices for conservation efforts. Additionally, county governments are encouraged to develop localised fisheries management plans aligned with national guidelines to ensure consistency in fish welfare practices (Kenya Fisheries Service, 2023; Opiyo *et al.*, 2023). Despite legislative progress, the absence of a dedicated Fish Welfare Policy has led to uncoordinated efforts, especially concerning fish transport guidelines. This gap has contributed to welfare issues such as overcrowding, poor water quality, and increased fish stress. Limited enforcement capacity, awareness gaps among farmers, and a shortage of trained aquatic veterinarians further hinder the implementation of effective welfare practices (Gatimu, 2022; Opiyo *et al.*, 2023).

National Fisheries Policy (2020)

The National Fisheries Policy (2020) promotes sustainable fisheries management, recognising fish welfare as critical to productivity and public health. The policy encourages stakeholder involvement, capacity building, and financial support for marginalised groups, such as women and youth, to enhance participation in fisheries (Ministry of Agriculture, 2020).

Kenya Fisheries Service Strategic Plan (2023-2027)

The KeFS Strategic Plan (2023-2027) emphasises sustainable fisheries development while promoting fish welfare. Key strategies include enhancing conservation efforts, increasing stakeholder engagement, and adopting modern technologies to improve fish well-being (KeFS, 2023).

Environmental Regulations by NEMA

The National Environment Management Authority (NEMA) enforces pollution control measures to maintain clean and safe water for aquaculture. These regulations are crucial for maintaining suitable aquatic environments that support the health and welfare of fish (NEMA, n.d.).

Recommendations for fish welfare legislation in Kenya

To improve fish welfare standards in Kenya, the following recommendations are proposed:

1. **Develop a dedicated Fish Welfare Policy:** To establish a clear species-specific guideline on handling, stocking densities, feeding, and transportation to improve compliance.
2. **Strengthen transport guidelines:** Enhance fish transport practices to minimise stress and mortality, with a focus on oxygen management, stress reduction, and acclimatisation.
3. **Improve disease surveillance systems:** Increase the number of trained aquatic veterinarians to enhance disease prevention and ensure timely interventions.
4. **Expand farmer training programs:** Conduct nationwide training initiatives involving county governments, research institutions, and NGOs to raise awareness and promote improved welfare practices.
5. **Increase resource allocation:** Ensure adequate government funding and foster partnerships with international organisations to improve enforcement capacity and provide technical support.
6. **Promote stakeholder collaboration:** Engage fish farmers, researchers, policymakers, and veterinarians to establish robust welfare standards and ensure sector-wide compliance.

Q&A session

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

If you are reading the training manual on your own, you can share your questions in the following ways to receive answers and further support, if 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 forum

Reflect on the topic of animal welfare in general. Were you aware of the concept of "animal welfare" before now? Did you consider it important in the management of animals? Have you ever considered animal welfare in your daily life? 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 enhances human well-being and environmental health?

Discuss general animal welfare practices and violations in Kenya. Which of the animal welfare violations listed are common in Kenya? What can be done to address and prevent poor animal welfare practices in Kenya?

Share your thoughts and feedback on the animal welfare legal framework in Kenya. Is it sufficient? Are there gaps? What recommendations do you have? What can be done to push for the establishment and implementation of the Animal Welfare Law (including fish welfare) in Kenya? How can you support this?

MODULE 3: FISH WELFARE

Introduction to fish welfare

What is fish welfare in aquaculture?

Fish welfare refers to the physical and psychological well-being of fish throughout their lifecycle, from breeding and hatching to grow-out, harvesting, handling, and transport. Fish welfare in aquaculture is categorised into three key definitions. Emotional experience-based welfare emphasises reducing negative experiences and enhancing positive ones, while functionality-based welfare focuses on physiological health and the ability to adapt to environmental changes. On the other hand, nature-centric welfare stresses the importance of fish exhibiting natural *behaviours*. While safeguarding cultured fish from all negative experiences is unrealistic, striking a balance between positive and negative experiences is crucial for their well-being. Assessing the emotional states of wild fish is also challenging without containment.

Fish welfare principles in Kenya

Fish welfare in Kenya is influenced by factors such as proper nutrition, effective water quality management, controlled stocking density, and stress reduction. Poor handling during fish translocation, particularly of fingerlings or fry, is a significant contributor to stress and disease transmission (Opiyo *et al.*, 2023). Intensive cage culture often elevates nutrient levels, promoting parasite proliferation, while high concentrations of unionised ammonia and human faeces can increase fish susceptibility to gastrointestinal parasites, particularly in common carp. Predator attacks may also cause injuries that lead to secondary infections, with birds and mammals contributing to the life cycles of parasites. To mitigate these risks, farmers are encouraged to adopt natural treatments, environmentally friendly pesticides, and biosecurity measures, such as quarantine protocols. Key challenges to fish welfare in Kenya include poor water quality, overcrowded fish populations, and a shortage of fish health specialists.

With the support of KeFS, fish farmers can significantly improve the welfare, health, and productivity of their stock, contributing to a more sustainable aquaculture industry in Kenya. KeFS achieves this by developing comprehensive policies and guidelines for proper fish husbandry, providing training *programmes* to enhance aquaculture management, promoting technological innovations to address issues like poor water quality and overcrowding, and collaborating with international organisations to integrate global best practices into local aquaculture systems (KeFS, 2023).

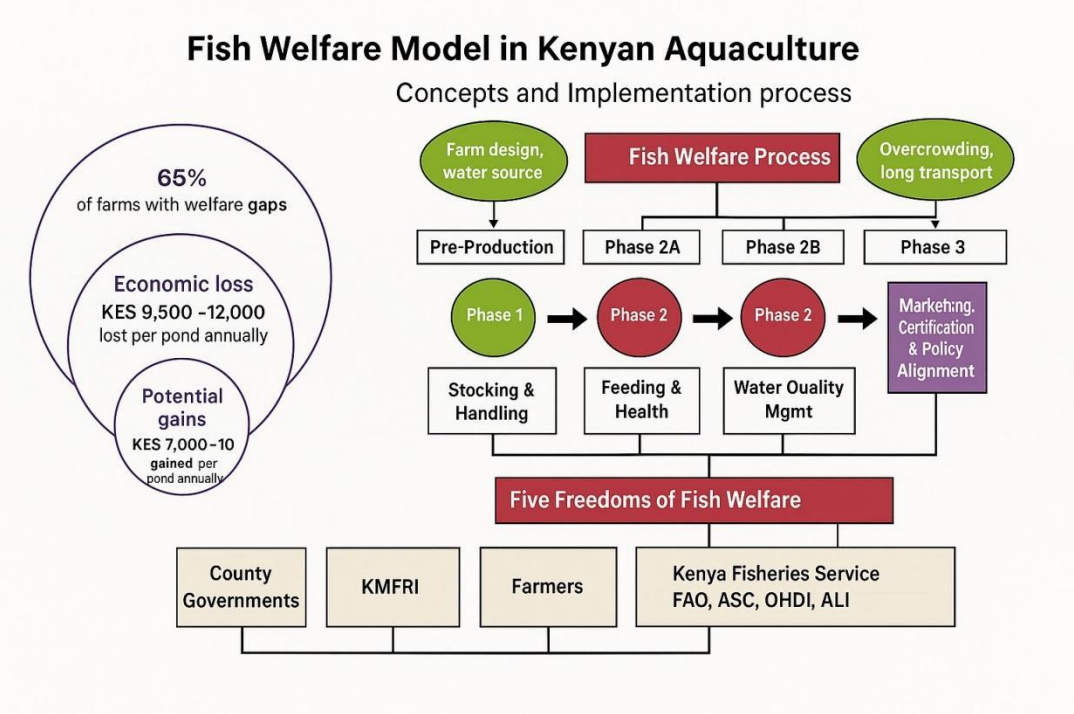

Figure 6 Understanding the fish welfare concept and its implementation in aquaculture

Benefits of improved welfare in cultured fish

Improved fish welfare in aquaculture provides several significant benefits:

1. Enhanced fish health and biosecurity: Humane treatment reduces disease incidence, mortality rates, and parasite infestations. Fish raised in good welfare conditions exhibit normal *behaviour*, maintain proper reproductive cycles, and have improved immune function, ultimately boosting productivity (Madzingira, 2017; FAO, 2022).

2. Improved quality of life: Better welfare conditions minimise stress, allowing fish to express natural *behaviours* and thrive in optimal environments. Reduced stress improves both physical and mental well-being (Keeling *et al.*, 2018).

3. Compliance with trade and consumer demands: Welfare-centred practices help farmers meet emerging consumer expectations and adhere to international trade regulations. This improves market access and builds consumer trust in ethically sourced fish products (Muiño *et al.*, 2024).

4. Increased productivity and profitability: Welfare-focused practices enhance production efficiency by reducing aggression, minimising fin damage, and improving feed conversion rates. These improvements lead to faster growth, healthier fish, and better financial returns for farmers (FAO, 2022).

5. Improved food quality and safety: Fish raised in stress-free conditions are tastier, healthier, and less prone to bacterial contamination, ensuring high product quality and safer consumption.

6. Environmental sustainability: Better welfare practices reduce wastewater pollution, minimise antimicrobial use, and prevent the escape of non-native species, which can threaten local ecosystems (Kenya Fisheries Management and Development Regulations, 2024).

7. Contribution to sustainable development goals (SDGs): Enhancing fish welfare aligns with and promotes SDGs as highlighted below:

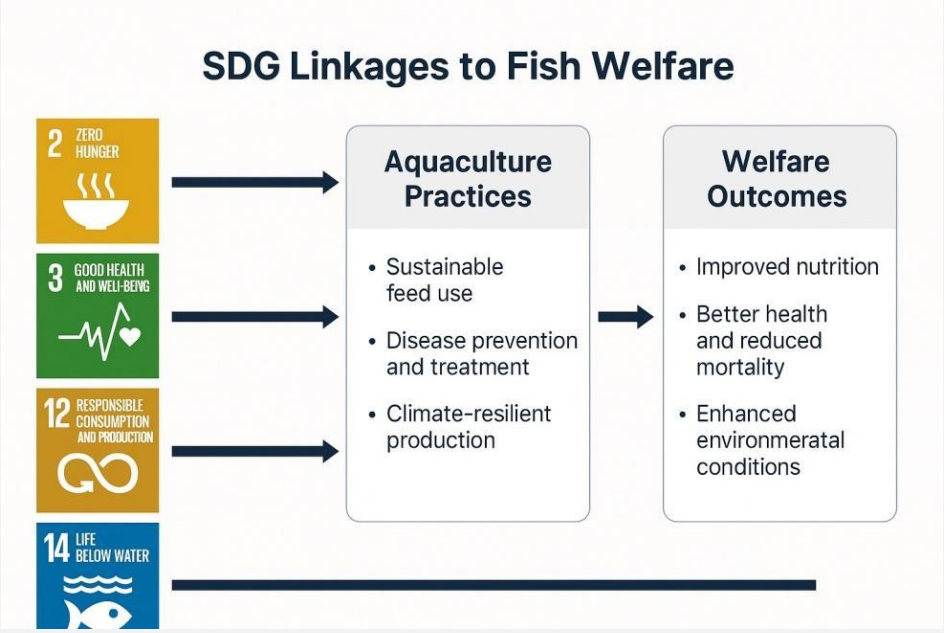

Figure 7 Linkage of Sustainable Development Goals (SDGs) to Fish welfare

- **SDG 1 (No poverty):** by improving fish health, increasing productivity, and providing a stable income for aquaculture farmers.
- **SDG 2 (Zero hunger):** by enhancing food and nutrition security, particularly among developing countries.
- **SDG 3 (Good health and well-being):** by ensuring safer and healthier fish for consumers.
- **SDG 6 (Clean water and sanitation):** by minimising wastewater contamination through improved feeding efficiency, reduced chemical use and practising circularity.
- **SDG 12 (Responsible consumption and production):** by reducing environmental footprints and promoting ethical farming methods.
- **SDG 14 (Life below water):** by minimising disease transmission between farmed and wild fish and reducing ecological damage.
- **SDG 17 (Partnerships for the Goals):** is supported through collaboration among stakeholders such as researchers, policymakers, and industry players to promote sustainable aquaculture practices.

The Right Thing for Fish

The concept of "The Right Thing for Fish," adapted from the Fish Welfare Initiative (FWI), underscores the critical importance of prioritising fish welfare within the rapidly expanding aquaculture industry. As aquaculture now represents over 50% of global seafood production and supports habitats for 73 to 180 billion fish at any given time, welfare issues such as diseases, overcrowding, poor handling, and inadequate water quality are significant concerns (Richie, 2019). These factors can lead to chronic stress in fish, resulting in high mortality rates.

Recognising that fish are sentient beings capable of experiencing pain, there is a moral obligation to ensure their well-being, even in the absence of specific legal requirements. Browning (2023) emphasises the need for greater attention to fish welfare assessment in aquaculture, advocating for the development of improved evaluation frameworks and best-practice welfare assessment processes. This approach aims to establish and maintain high welfare standards, ultimately enhancing the quality of life for fish in aquaculture settings. By addressing these welfare concerns, the industry can promote more ethical and sustainable practices that benefit both fish and consumers.

Table 1 Global fish and animal welfare certification schemes

Certification Body	Animal welfare content	Fish welfare content	Additional information
Aquaculture Stewardship Council (ASC)	Yes	Yes	Comprehensive fish welfare standards.
Global Animal Partnership (G.A.P.)	Yes	Yes	Includes detailed fish welfare criteria.
RSPCA Assured	Yes	Yes	Focuses on both animal and fish welfare.

Naturland	Yes	Yes	Incorporates fish welfare in standards.
Friend of the Sea	Yes	Yes	Includes fish welfare components.
GLOBALG.A.P.	Yes	Limited	Primarily animal welfare, with less focus on fish.
Best Aquaculture Practices (BAP)	Yes	Yes	Comprehensive standards for fish welfare.

Note: Animal/fish Welfare Content: Indicates whether the certification scheme includes general animal welfare principles and/or provides specific guidelines or standards focused on the welfare of fish.

Animal welfare practices and interventions

Effective animal welfare practices in the Kenyan aquaculture sector are essential for minimising stress, promoting fish health, and improving production efficiency. Fish are often bred in hatcheries and raised in controlled environments that differ from their natural habitats, posing welfare challenges such as overcrowding, poor water quality, and restricted natural *behaviour*s (Animal Charity Evaluators, 2020; Fish Welfare Initiative, 2019). Overcrowding can increase stress, trigger aggressive *behaviour*, and heighten disease risks (Ashley, 2007). Additionally, inadequate water quality management, often associated with poor filtration and inadequate oxygenation, can lead to respiratory problems and increased mortality rates (Browning, 2023). Key strategies to enhance the welfare of cultured fishes include:

- Optimising culture system design to allow free movement of fish, selecting resilient species such as *C. gariepinus*, *O. niloticus*, and *O. mykiss* (Ritchie, 2019), and managing stocking densities to reduce competition and stress.
- Maintaining proper water quality through aeration, filtration, and regular monitoring is crucial. For instance, *O. niloticus* thrives in well-oxygenated

water, and common carp benefit from stable water conditions to support growth and reproduction (Cerqueira and Billington, 2024).

- Implementing effective feeding and disease prevention strategies.
- Addressing the species-specific needs, such as providing spacious environments for *C. gariepinus* to reduce aggression.

Discussion points

1. What new knowledge have you gained from this training on fish welfare today?
2. Drawing from your experience on your own fish farm (or working with fish farmers), how do you plan to adapt and *utilise* your knowledge of the "Five Pillars of Animal Welfare in Aquaculture"?
3. Among all the benefits listed, what are the top 3 benefits you look forward to achieving by implementing fish welfare practices? Why?

MODULE 4: GROWING SYSTEMS AND FISH WELFARE

This module offers guidance on selecting and evaluating suitable sites for fish farms. It provides detailed information on the various types of growing systems and their respective welfare concerns, and explains best practices for stocking density.

Introduction to growing systems

Before establishing a fish farm, it is essential to plan properly and consider factors that impact fish health and welfare, as these significantly affect fish health, productivity, and investment returns (Chentouf *et al.*, 2023). Each system presents unique challenges and benefits. For instance, pond culture can support optimal fish welfare if managed properly; however, most often, poor water exchange and waste buildup can degrade water quality, leading to stress and disease.

Cage culture, typically used in large water bodies, exposes fish to natural environmental conditions; however, overcrowding and limited control over water quality can increase stress and disease risks. Recirculating aquaculture systems (RAS) offer improved water quality control through advanced filtration and aeration, but require careful monitoring to prevent equipment failure, which can quickly compromise fish welfare. Proper system management, including regular monitoring of water quality, optimal stocking densities, and appropriate feeding strategies, is essential for maintaining fish welfare across all rearing systems (Omweno and Omondi, 2024).

Site selection for fish farms

Selecting an appropriate site is crucial for ensuring the success, sustainability, and welfare of fish in aquaculture systems. Key considerations include environmental conditions, construction standards, and social acceptance.

A. Environmental considerations

When choosing a fish farm location, environmental factors must be carefully evaluated to minimise risks to fish welfare and infrastructure. According to FAO (2008), Farms should be situated away from:

- Industrial areas, commercial farms, and flood-prone zones to prevent contamination from pollutants such as industrial waste, effluents, fertilisers, and sewage, which can degrade water quality, cause fish stress, increase disease risks, and lead to mortality
- They should also be far from high tidal waters, strong currents, and noisy environments, as these can damage infrastructure, disrupt breeding, and induce stress in fish. Considering extreme weather events linked to climate change is also essential to ensure the farm's structural resilience. Due to the above impacts, an Environmental Impact Assessment should be done to establish the fish farm.

Environmental Impact Assessment (EIA)

Conducting an Environmental Impact Assessment (EIA) is essential before establishing a fish farm. An EIA identifies potential environmental risks and outlines mitigation strategies to minimise harm to local ecosystems (FWI, 2021). The key EIA considerations include:

- Water quality and sediment conditions.
- Impact on natural populations that may be affected by aquaculture activities.
- Pollution control and waste management measures to sustain a healthy environment for aquatic life.

The EIA promotes environmental sustainability, demonstrates responsible stewardship, and improves acceptance by local communities and regulatory bodies. It also establishes a framework for ongoing environmental monitoring and evaluation, ensuring continuous improvement (FWI, 2021).

B. Construction standards

Fish farm structures must adhere to recognised construction standards to ensure durability and environmental safety. Obtaining necessary permits and conducting hydrological studies are crucial before commencing construction to prevent damage to infrastructure and environmental degradation (Rana, 2007). Other key factors that ensure efficient operations and fish welfare include:

- Farm accessibility for easy monitoring and management.
- Reliable water supply with consistent quality.
- Availability of veterinary care and medications.
- Suitable farm layout and topography to optimise water flow and minimise erosion risks.
- Community acceptance, ensuring the project aligns with local interests and environmental concerns.

Fish welfare considerations for rearing systems

Figure 8 A liner pond used for semi-intensive aquaculture production in Kisii County, Kenya

Each Kenyan aquaculture system, whether extensive, semi-intensive, or intensive, presents unique advantages and challenges that influence fish welfare through their design, management practices, and environmental controls. For example,

extensive systems offer a natural environment but face challenges in disease control, feeding efficiency, and environmental stability. Semi-intensive systems strike a balance between fish welfare and productivity, although poor management can increase disease risks. Intensive systems provide precise control over environmental conditions; however, they require skilled personnel, high maintenance, and careful management to mitigate welfare issues associated with overcrowding and system failures.

Table 2 Comparative analysis of fish welfare in different aquaculture systems used in Kenya

Aspect	Extensive systems	Semi-intensive systems	Intensive systems
Examples	Earthen ponds, lagoons and small pens	Earthen ponds, liner ponds, concrete ponds and cages	RAS, flow-through systems, biofloc systems, cages, Aquaponics, raised ponds, mobile ponds
Water control	Minimal control; dependent on natural conditions (Munguti *et al.*, 2021)	Moderate control; Water quality management required to prevent sedimentation and nutrient build-up (Munguti *et al.*, 2021)	High control; Precise regulation of pH, temperature and dissolved oxygen levels (Munguti *et al.*, 2021)
Feeding practices	Natural feeding with minimal supplementary feeding (Omweno and Omondi, 2024)	Combination of natural food organisms with supplemental feed (Omweno and Omondi, 2024)	Primarily relies on commercial feed or formulated diets (Omweno and Omondi, 2024)

Stocking density	Low; reduces stress and disease risks (Ngugi *et al.*, 2007)	Medium; requires monitoring to prevent overcrowding and poor water quality (Ngugi *et al.*, 2007)	High; requires careful management to prevent stress, aggression and disease (Ngugi *et al.*, 2007)
Disease risk	Lower risk due to minimal handling and lower stocking densities (Diana, 2012)	Moderate risk, especially if water quality is not well managed (Diana, 2012)	High risk due to increased density, handling and reliance on artificial systems (Diana, 2012)
Environmental enrichment	Natural environment allows for natural behaviours and improved welfare (Opiyo *et al.*, 2018)	Natural features present but may require enrichment to improve welfare (Opiyo *et al.*, 2018)	Often lacks natural features; enrichment measures (Opiyo *et al.*, 2018)
Stress factors	Lower stress due to a natural environment and less frequent handling (Opiyo *et al.*, 2018)	Moderate stress; sorting, cleaning and maintenance can cause disturbance (Opiyo *et al.*, 2018)	Higher stress levels, confined spaces, frequent handling and system failures (e.g. power loss) pose serious risks
Predation risks	High risk of predation; requires protective measures	Moderate risk; enclosures and screens can minimise predation threats	Minimal risk in an enclosed system like RAS; Cages are vulnerable unless well managed
Economic viability	Low initial investment and operational costs;	Moderate costs; provide better returns	High initial and operational costs;

	suitable for small-scale farmers	with improved management	demands technical skills and equipment
Sustainability	Environmentally friendly with minimal energy use, but prone to pollution	Balances environmental impact with improved productivity	RAS and aquaponics systems improve sustainability through water reuse; Biofloc systems minimise waste discharge.

To ensure optimal fish welfare, farmers should choose systems that align with their resources, technical expertise, and production goals. For example, extensive systems may suit low-input rural setups, semi-intensive systems offer improved yields with moderate investment, and intensive systems, though costly, provide enhanced environmental control for better fish welfare and productivity when managed effectively.

Stocking density and rearing systems

Stocking density refers to the number of fish or the total biomass present in a unit volume of water. It is a critical factor in aquaculture that directly affects fish welfare, health, and overall productivity. The stocking density of a given culture system is calculated using the following formula:

Stocking density = Total biomass (g or Kg) / Volume of water (L or m^3)

Stocking density plays a significant role in Kenyan aquaculture systems, with its impact varying depending on the rearing method, fish species, and environmental conditions. Effective management is essential to achieving a balance between maximising productivity and maintaining fish welfare.

Stocking density guidelines for fish welfare and certification

Regulatory and evidence-based framework

Regulatory clarity: Regulations for stocking density and space requirements must be explicitly stated within the farmed standards to ensure compliance and promote fish welfare.

Evidence-based guidelines: Stocking density ranges should be based on the best scientific evidence for specific species and life stages, as well as the type of rearing system (e.g. RAS, sea cages, flow-through systems).

Number of fish per volume and fish welfare focus

The number of fish per volume considered for stocking must account for interrelated farming parameters, including disease, stress, water quality, and welfare indicators, and should be adjusted as necessary to ensure optimal conditions. This will allow the stocking densities to prioritise fish welfare by allowing ample space for natural *behaviour*s and social interactions, rather than being set solely for maximum production potential.

System-specific recommendations

Pond systems: Extensive Pond systems generally operate at lower stocking densities (e.g. 7 fish/m^2 for catfish) to reduce stress and ensure better water quality. Intensive pond culture systems may allow higher densities (e.g. 50 fish/m^2 for African catfish), but require robust water management due to increased waste accumulation.

Cage systems: For Nile tilapia, recommended stocking densities are 120 fish/m^3. However, poor density control can lead to localised pollution and disease outbreaks, highlighting the need for careful management.

Tank and raceway systems: These systems offer better control over water quality. Technologies like artificial intelligence in RAS can help maintain optimal conditions, supporting higher stocking densities without compromising welfare.

Species-specific and environmental considerations

- African catfish can reach 250 fish/m^2 in intensive systems, but lower densities are recommended for larvae (100 fish/m^2) and fingerlings (35–40 fish/m^2) to ensure survival.

- Nile tilapia's recommended density of 120 fish/m³ balances productivity and welfare, while common carp can reach 25 fish/m² in cage culture, necessitating careful water quality management.
- Environmental conditions such as temperature, dissolved oxygen, and water flow are critical in determining suitable stocking densities. Systems with better oxygenation, such as RAS, can sustain higher stocking rates while maintaining high welfare standards.

Implications for fish welfare and mitigation strategies

Higher stocking densities can induce stress, increase aggression, and impair immune responses, making fish more vulnerable to diseases. For example, salmon and rainbow trout exhibit behavioural issues in crowded environments. To mitigate these risks, Kenya's aquaculture sector must adopt species-specific stocking densities, supported by water quality monitoring, *behaviour*al assessments, and effective feeding practices.

Q&A Session

In a facilitator-led training session, fish welfare trainers or facilitators should provide opportunities for trainees to ask questions and engage them in discussions about the module. In addition, they should provide clear and comprehensive answers to trainees' questions.

If you are reading the training manual on your own, you can still receive answers and further support for your questions by using the following methods:

- 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

1. Discuss each of your current growing systems for your fish farms. What problems are you currently facing on your farm?

2. Did you conduct any analysis or evaluation of your farm sites before making your decision? Share your findings and the reasons behind your current system choice.

3. Based on what you have learned so far, how do you intend to improve the growing system and site of your farm to align with good fish welfare practices?

4. 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?

5. Based on what you have learned so far, what challenges have you been experiencing with your fish farm's stocking density? How do you intend to improve your fish farm's stocking density going forward?

MODULE 5: WATER QUALITY AND FISH WELFARE

Water quality parameters

Water quality is crucial for the welfare of cultured fish, which have different specific environmental needs to thrive. The parameters of water quality significantly impact fish welfare by directly influencing physiological stress responses, behaviour, immune function, growth rates, and overall health. For instance, low dissolved oxygen (DO) levels and high ammonia concentrations can lead to increased stress, gill damage, suppressed immune responses, elevated disease risks, and higher mortality rates (Boyd, 2020; Kumar *et al.*, 2017; Rakocy *et al.*, 2013). In tilapia and catfish culture, managing ammonia and nitrite build-up is a primary challenge. Rainbow trout, due to their sensitivity, require stringent control of DO, temperature, and oxidation-reduction potential (ORP). Among the cultured tilapia species, *Oreochromis niloticus* is more resilient to varying water quality conditions, while other species, such as *Oreochromis jipe*, are more sensitive to fluctuations (Omweno *et al.*, 2024).

Catfish are generally better at tolerating unstable environments compared to tilapia and rainbow trout, which need more stable conditions for optimal health. However, low dissolved oxygen (DO) levels below 2.91 mg/L and high ammonia concentrations can suppress appetite, slow growth, and increase vulnerability to disease (Boyd, 2020). On the other hand, the Common carp, *Cyprinus carpio*, requires relatively stable conditions with moderate temperatures and pH levels. While tolerant of varying oxygen levels, excessive turbidity can reduce feeding efficiency and growth performance (FAO, 2022). To address system challenges, effective water quality management is essential for maintaining the stability of aquaculture production systems and providing a conducive environment for fish growth and well-being. Key management practices include:

- ✓ **Optimal stocking densities**: Ensuring appropriate stocking densities contributes to improved fish welfare and productivity (Boyd, 2020; FAO, 2022; Youth Aquaculture Society, 2024).
- ✓ **Waste management**: Proper waste management is critical to prevent the build-up of harmful substances (Emam *et al.*, 2024).
- ✓ **Feeding regimes**: Implementing better feeding schedules helps prevent overfeeding or underfeeding, which can lead to excessive fertilisation and oxygen-depleting algal blooms (El-Sayed, 2020).
- ✓ **Regular monitoring**: Continuous monitoring of water quality, including water exchange or recirculation rates, is vital for maintaining optimal conditions.
- ✓ **Aeration and bio-filtration**: Utilising efficient aeration and bio-filtration systems can significantly improve water quality by reducing toxic compounds and enhancing water clarity (El-Sayed, 2020; FAO, 2022).

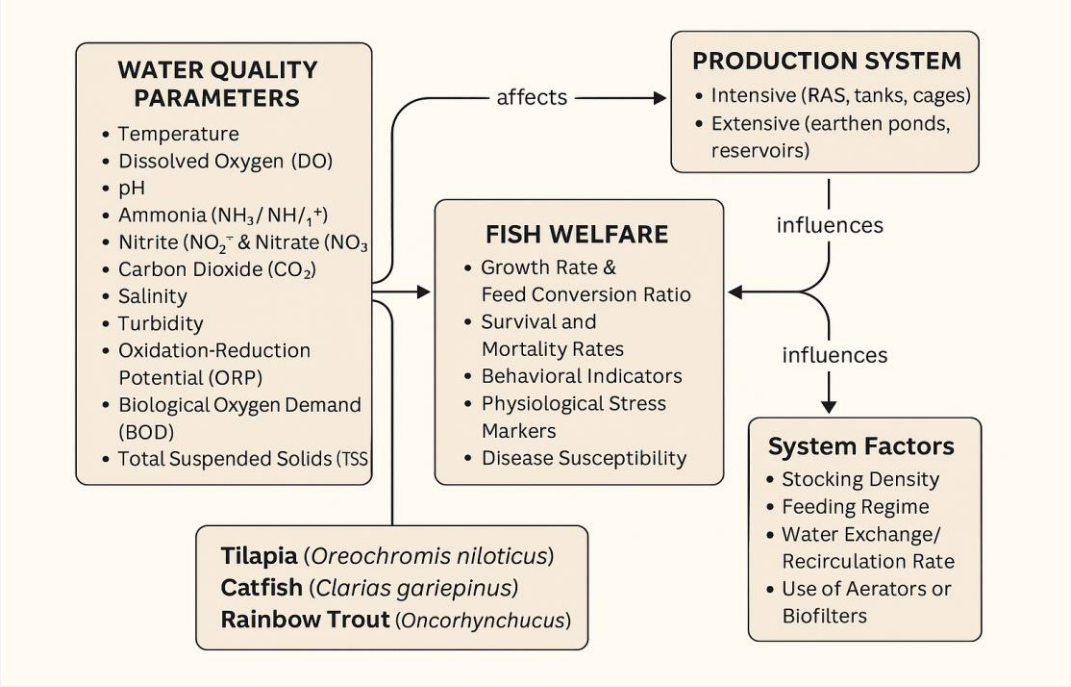

Figure 9 Interaction between water quality and fish welfare in different aquaculture systems

Maintaining optimal temperature, dissolved oxygen and pH levels are essential practices for promoting fish health (Rakocy *et al.*, 2013). Managing water quality

in aquaculture systems is important for optimising fish welfare and productivity in both intensive and extensive aquaculture systems. However, poorly managed systems can lead to stress accumulation, disease outbreaks, and suboptimal growth.

Species-specific water quality requirements

Table 3 Water quality requirements for different fish species (Adapted from OHDI, 2023; Boyd, 2020; El-Sayed, 2020; FAO, 2022; Rakocy et al., 2013)

Parameters	Catfish	Tilapia	Rainbow trout
Temperature	26°C-32°C	20.2 - 31.7°C	20 - 18°C (FAO, 2022)
Dissolved Oxygen (DO)	2.91 - 4.85 mg/L	5 - 7mg/L	>7 mg/L (Boyd 2020)
pH	6.5 - 8.5	6 - 8.5	6.5 - 8.0 (FAO, 2022)
Ammonia	0.34mg/	0.14mg/l	< 0.02 mg/L (Boyd 2020)
Nitrite	1.19 mgL-1 (2% of LC50-96h)	0-7mg/L	<0.01mg/L (Rakocy *et al.* 2013)
Nitrate	400 ppm nitrate	5-500ppm	< 20ppm (FAO, 2022)
Alkalinity	4.56mg/L	1.6to9.3mg/L	20-200 mg/L (Boyd 2020)

Water hardness	25-50mg CaCO3L-1	401.33mg/lto634.00 mg/L	30-300 mgCaCO3/L (Boyd 2020)
Turbidity	Below 88 mgL-1	200mg/L	<25mg/l

Water quality guidelines for fish welfare and certification

To ensure optimal fish welfare, farms and regulatory authorities should adhere to the following water quality guidelines:

Regulatory and evidence-based framework: Regulations addressing water quality must be explicitly stated within the farmed standards. Evidence-Based: Ranges should be based on the best available scientific evidence to effectively promote fish welfare.

Optimal water quality parameters: Maintain optimal ranges for key water quality parameters, including:

- Dissolved Oxygen (DO): critical for fish respiration.
- Temperature: Essential for metabolic processes.
- pH: Affects metabolic functions and varies by species and life stage.
- Ammonia: Toxic at high levels; acceptable concentrations must be defined to ensure fish health.

Specificity of water quality ranges: Optimal ranges for dissolved oxygen, pH, and ammonia must be:

- Species-specific: Different fish species have varying tolerances.
- Life stage-specific: Juvenile and adult fish may have different requirements.
- Rearing System-Specific: Conditions may differ between Recirculating Aquaculture Systems (RAS), cages, flow-through systems, etc.

Water quality management plans

Each aquaculture operation must implement a site-specific water quality management plan that includes:

- Effective monitoring practices: Regular monitoring of water quality parameters to ensure they remain within optimal ranges.
- Contingency plans: Preparedness for emergencies such as system failures, algal blooms, and natural disasters, outlining steps to mitigate risks and protect fish welfare.

MODULE 6: FEEDING AND FISH WELFARE

Effective feeding practices are crucial to fish welfare, as they significantly impact growth, health, and overall productivity. In Kenyan aquaculture, where small-scale fish farming is prevalent, ensuring proper nutrition is crucial for improving yields and maintaining sustainable practices. Achieving this requires a balance between meeting fish nutritional requirements, adopting appropriate feeding strategies, and maintaining environmental stability.

Sustainable and ethical feeding practices

Complete and well-balanced diet

A well-balanced diet is crucial for fish, as it supports their growth, immunity, and overall well-being. Nutritional requirements vary by species; for instance, omnivorous fish like *O. niloticus* require 25-35% crude protein, while carnivorous species such as *C. gariepinus* and *O. mykiss* need higher protein levels of 40-50% for optimal development (El-Sayed, 2020; Halver and Hardy, 2021). In addition to proteins, essential vitamins and minerals play a crucial role in metabolic functions and disease resistance. Fat-soluble vitamins (A, D, E, and K) are stored in body tissues, whereas water-soluble vitamins, including vitamin C and the B-complex vitamins, must be replenished frequently to prevent deficiencies (Smith *et al.*, 2022). Trace elements such as selenium, zinc, and manganese are vital for immune function and skeletal development (Kumar *et al.*, 2021).

Overcoming the challenge of feed quality

The reliance on low-quality fish feed ingredients, such as maize bran and food remains, which are often cost-effective and locally sourced, can lead to substandard feeds. These feeds often have an improper nutrient balance and reduced digestibility, which contributes to water quality degradation. Consequently, this results in compromised fish growth and immune function, increasing disease susceptibility and negatively impacting fish health (Gitau *et al.*, 2021; Emam *et al.*, 2024). To enhance fish welfare, it is crucial for Kenyan farmers to prioritise high-quality feed formulations that incorporate alternative protein

sources, such as black soldier fly larvae, microalgae, and aquatic plants. These ingredients not only improve feed efficiency but also promote sustainability and reduce reliance on expensive locally manufactured or imported feeds (Omweno *et al.*, 2024).

Strengthening feed regulations, training, and sustainability in feeding

Strengthening feed regulations and providing training for farmers in proper formulation techniques are essential steps to ensure consistent feed quality (Munguti *et al.*, 2021). Sustainability in fish feeding is vital for environmental conservation and the long-term success of aquaculture. Over-reliance on fishmeal derived from wild fish stocks poses a threat to marine ecosystems. Alternative protein sources, including insect meal, microalgae, and aquatic plants, offer sustainable solutions that enhance fish welfare while minimising environmental impact (Omweno *et al.*, 2024).

Integrated aquaculture systems

Furthermore, Kenyan farmers are increasingly adopting integrated aquaculture systems that combine species like *O. niloticus* and *C. gariepinus*. These polyculture systems promote efficient feed utilisation, reduce feed waste, and help maintain ecological balance. Encouraging local feed production using alternative ingredients not only enhances food security but also lowers production costs (Ochieng *et al.*, 2020).

Feeding for fish welfare

Implementing proper feeding is an important strategy to maintain fish welfare and maximise productivity. These practices can help ensure optimal feeding outcomes:

Balanced feeding regimes

Feeding fish in appropriate quantities and at optimal intervals is crucial for their well-being. Overfeeding leads to excess waste, which degrades water quality and increases ammonia and nitrite levels (Boyd, 2020). On the other hand, underfeeding deprives fish of essential nutrients, compromising growth and

immune function. Monitoring feeding *behaviour* and adjusting feed quantities based on fish size, water conditions, and environmental factors ensures fish receive the right amount of food.

Reducing competition and ensuring accessibility

Competition for food can cause stress and unequal nutrition, particularly in mixed-size fish populations. Grading fish by size helps create uniform groups, ensuring smaller fish have equal access to food. Distributing feed across multiple points, covering approximately 75% of the pond or tank, further minimises aggression and promotes natural foraging behaviour (Yavuzcan Yildiz *et al.*, 2017).

Feed pellet size and texture

The size and texture of feed pellets must be appropriate for the fish species and their developmental stage. Pellets that are too large may be difficult to ingest, while overly small pellets may disintegrate before consumption. Soft, palatable pellets enhance intake and digestion, thereby reducing feed waste and promoting improved growth (De Silva and Anderson, 1995).

Feeding methods and technology

Selecting appropriate feeding methods enhances efficiency and welfare. Hand feeding allows farmers to observe fish *behaviour* and identify issues such as stress or illness. Automated feeders, when available, ensure controlled and consistent feeding schedules that minimise waste and reduce competition (Yue *et al.*, 2016). Facilities like the National Aquaculture and Research Training Centre (NARTC) in Sagana have demonstrated the effectiveness of automated feeding systems in improving feeding precision and fish welfare (Rutten *et al.*, 2004).

Environmental management and water quality

Feeding practices directly impact water quality. Overfeeding results in an excess of organic matter, which raises ammonia and nitrite levels that can harm fish health (Boyd, 2020). Maintaining clean water through regular monitoring, proper aeration, and waste removal is essential. Farmers should regularly assess water

parameters such as temperature, pH, and oxygen levels to maintain optimal conditions (Mwangi *et al.*, 2022).

Monitoring and adaptive strategies

Observing fish feeding patterns provides valuable insights into their health and welfare. Changes in feeding *behaviour* may indicate stress, illness, or nutritional deficiencies. Regular observation enables farmers to make timely adjustments to feeding rates, pellet size, or feed composition (Martins *et al.*, 2020; Yavuzcan Yildiz *et al.*, 2017).

Addressing feeding challenges in Kenyan aquaculture

Despite progress, Kenyan aquaculture continues to face persistent challenges in feed quality, affordability, and farmer training. Inconsistent feed standards and limited technical knowledge contribute to poor feeding practices that compromise fish welfare. Expanding farmer training *programme*s, promoting access to quality feed, and developing cost-effective alternatives are crucial to overcoming these barriers (Mwangi and Muturi, 2023). Feeding practices are vital to the welfare and productivity of fish in Kenyan aquaculture. By adopting balanced diets, improving feeding strategies, and embracing sustainable practices, farmers can enhance fish growth while maintaining environmental sustainability. Strengthening technical training, promoting local feed innovations, and encouraging responsible feeding practices are key to ensuring the long-term success of Kenyan aquaculture.

MODULE 7: FISH WELFARE DURING HANDLING AND TRANSPORTATION

This module provides guidelines tailored to Kenyan fisheries practices to promote optimal fish welfare during handling and transportation.

Introduction to fish handling and transportation

Handling and transportation are integral components of the fish production process. This encompasses activities such as vaccination, sorting and grading, tagging, and harvesting that impact fish health, productivity and production outcomes. For example, the processes are essential for moving fish within and between farms, as well as to markets and processing facilities. Chilvers (2013) reports that improper handling and transportation can induce significant stress and injury risks, presenting significant challenges to fish welfare. For instance, capture methods, including nets and pumps, can cause abrasions, scale loss, and other injuries while handling, damaging the protective mucus layer and increasing disease susceptibility. Therefore, adopting best practices is imperative to minimise stress and promote humane treatment of fish.

Transport, often necessary for all culture species, usually leads to prolonged stress responses, with cortisol levels in raising fish like salmon, which smolts take over 48 hours to normalise. Overcrowding during handling and transport can lead to aggression, causing eye and fin injuries, damage to the mucus production layer, scale loss, gill damage, muscle bruising and skin ulceration, and exposure to extreme environmental conditions. This results in susceptibility to pathogen and parasite infections (Adesina *et al.*, 2017). Stressful conditions during transport and pre- and post-transport phases can lead to severe physiological stress, high mortalities, and financial losses. Proper handling and transport techniques are essential to reduce stress and injury to fish, involving the use of appropriate equipment and methods to ensure fish are moved safely (The Fish Site, 2013).

Minimising stress during fish handling

Fish experience stress when exposed to adverse conditions, which can lead to compromised immune systems, reduced growth rates, and increased mortality. Common stressors during handling and transportation include:

- **Physical stressors:** Rough handling, overcrowding, and exposure to air.
- **Environmental stressors:** Fluctuations in water temperature, dissolved oxygen levels, and poor water quality.
- **Physiological stressors:** Elevated cortisol levels and metabolic disturbances.

These stressors are crucial for implementing practices that minimise their impact. Aquatic animals should be subjected to minimum stress during handling and transportation by implementing defined measures to ensure that these organisms are provided with conditions during transportation and slaughter that meet animal specific needs and minimise the adverse effects of (a) diminishing water quality (b) time spent in transport; (c) stocking density, (d) toxic substances; (e) escape.

Mitigating fish handling stress

Fish are highly sensitive to handling, and removing them from water triggers a pronounced stress response. Research indicates that fish possess stress physiology comparable to that of mammals and birds, underscoring the need for careful handling practices. In Kenya, common handling methods include the use of nets and manual transfer, which, if not properly managed, can lead to injuries and increased susceptibility to diseases. To mitigate these risks, it is recommended to adopt best practices or proper handling techniques that reduce stress and physical injuries to fish (Biochem Team, 2022). These include:

i. Handling fish only when necessary.
ii. Live fish should be handled in ways which are compatible with their physiological requirements. Limit the duration fish are kept out of water, ideally less than 15 seconds, unless anaesthetised.
iii. Minimise handling by transporting fish without removing them from water.

iv. Maintain appropriate hauling densities.

v. Use appropriate equipment such as soft, smooth, knotless nets and ensure all handling tools are clean and sanitised to prevent physical injuries and infections.

vi. Handle fish when temperatures are low and use temperature-controlled tanks fitted with aerators, often made from thermally non-conductive materials, to help stabilise and maintain water temperature at optimal levels.

vii. Ensure gentle handling: Use wet hands or gloves to prevent scale loss and skin damage. Avoid squeezing or dropping fish and support their body weight during transfer.

Figure 10 Steps in introducing fish fingerlings during stocking

Negative impact of poor handling

Inadequate handling practices can result in:

- **Physical injuries:** Such as scale loss, fin damage, and bruising.
- **Compromised immune function:** Stress from poor handling can suppress the immune system, increasing disease susceptibility.
- **Reduced growth and productivity:** Chronic stress can impair growth rates and overall farm productivity.

Therefore, implementing proper handling techniques is essential to maintain fish health and optimise aquaculture yields.

Fish welfare during transportation

Best practices in the transportation of fish

Transporting live fish involves multiple stages, including capture, loading, conveyance, and unloading. In Kenya, fingerlings or juvenile fish are commonly transported from hatcheries to farms or cages, and live fish are harvested and transported to slaughter facilities. Each phase induces potential stressors, such as:

- **Overcrowding:** High stocking densities can lead to oxygen depletion and accumulation of waste products.
- **Water quality deterioration:** Fluctuations in temperature, oxygen levels, and the buildup of carbon dioxide and ammonia can adversely affect fish health (Adesina *et al.*, 2017).
- **Physical handling:** Improper loading and unloading techniques can cause injuries.

A study focusing on live fish transportation in Kenya highlighted that temperature and oxygen fluctuations are significant challenges across all regions, particularly in Mombasa and Kisumu (Syanya *et al.*, 2024). The study also noted that common transport methods include sealed tanks, plastic bags, and purpose-built vehicles, each with its own set of challenges and considerations (Syanya *et al.*, 2024).

Methods and equipment for transport

The transportation of live fish in Kenya involves various methods, each with specific considerations:

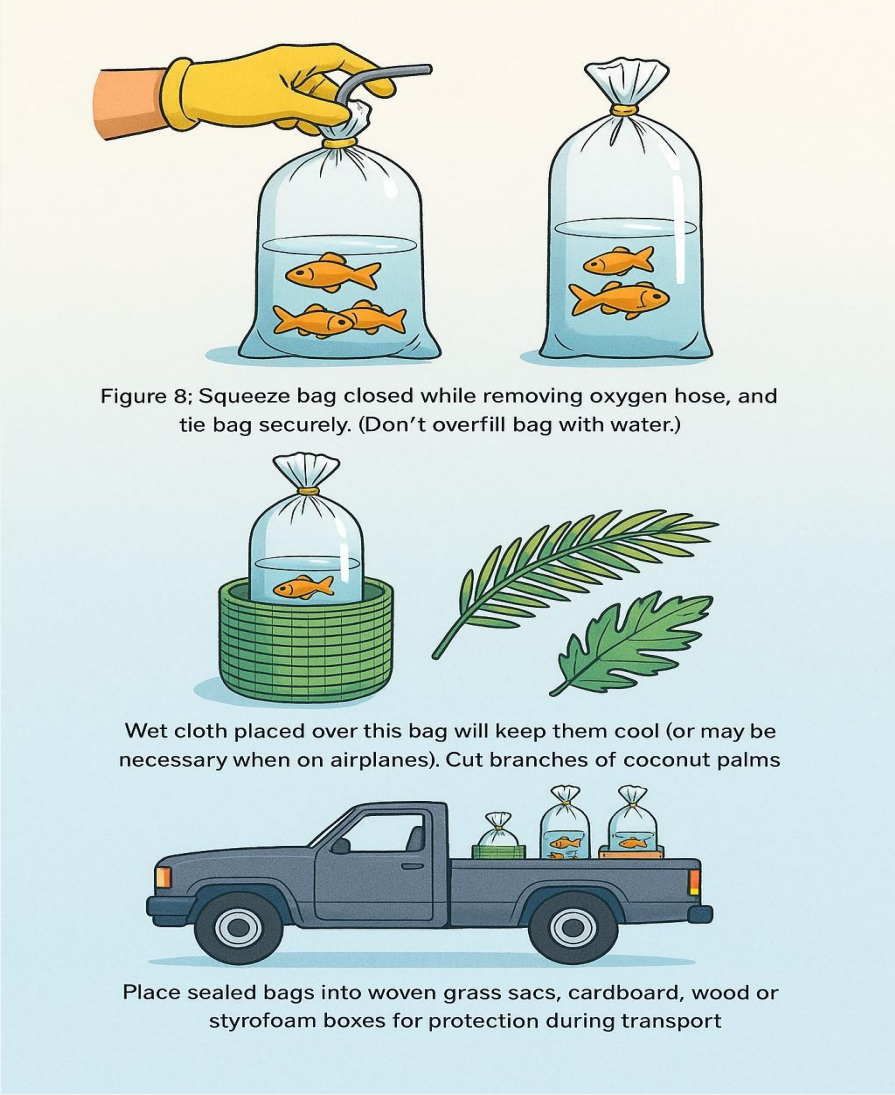

Figure 11 Common methods of fish transportation in Kenya

In small-scale transportation, sealed plastic bags with oxygenation are commonly used for transporting fingerlings or small fish over short distances. Modified vehicles fitted with tanks or containers are designed to prevent injury and maintain water quality, mainly dominated by private cars and modified vans (Syanya *et al.*, 2024). They include purpose-built vehicles with aerated tanks, suitable for transporting larger quantities of fish over longer distances, as well as modified vans

and public transport, which may lack adequate facilities to maintain optimal water quality and temperature, but are prevalent in areas such as Central Kenya and Nairobi (Syanya *et al.*, 2024).

Preparation of live fish for transport

Fish preparation for transport is important to reducing stress during transportation. Pre-transport considerations include:

i. Acclimatisation of fish to adjust to transport conditions, including temperature and water quality, reducing temperature shock.
ii. Withholding feed for 24 hours before transport to reduce metabolic waste generation, which can deteriorate water quality during transit.
iii. Consider water quality management to maintain the recommended optimal levels of temperature, dissolved oxygen and pH.
    - These include the use of aeration systems to supply and maintain adequate dissolved oxygen levels, use of insulating, heating or cooling systems in transportation tanks to maintain optimal temperatures or avoid sudden or abrupt changes in water temperature, which can cause thermal shock, leading to increased mortality rates and limiting ammonia buildup by minimising stress and maintaining water quality.
iv. Adding salt to transport water can alleviate osmo-regulatory stress, but the correct concentration must be determined for each species.
v. Use gentle/appropriate handling equipment and techniques to minimise physical stress and injury during loading and unloading.
vi. Avoid overcrowding and adhere to recommended densities based on species and size.
vii. Use of recommended doses of anaesthetics to reduce stress during handling and transport. Ensure compliance with local regulations regarding the use of anaesthetics in food fish. Although sedation can significantly mitigate stress, commonly used anaesthetics are not universally licensed,

prompting welfare organisations to advocate for minimal transport and improved handling practices to reduce suffering (Chilvers, 2013).

viii. Adherence to legal and ethical standards **-** Adherence to standard protocols, legal frameworks and ethical standards is essential. These include the standard guidelines outlined in the Kenya National Animal Welfare Strategy and Action Plan (2017-2022), which provides comprehensive guidelines on the welfare of farmed fish during transportation (FAOLEX, 2017). Additionally, the Kenya Marine and Fisheries Research Institute (KMFRI) has established regulations to be followed during fish transportation to minimise mortality. These local practices should be aligned with international standards, such as those by the World Organisation for Animal Health (WOAH).

ix. Training and continuous improvement **-** Regularly train fish handlers and transporters and equip them with the necessary skills and knowledge to manage fish welfare effectively during transport. Trained personnel are able to implement protocols to monitor fish welfare and adjust practices as needed.

MODULE 8: SLAUGHTERING AND FISH WELFARE

Overview of humane fish slaughter practices

Kenya's aquaculture sector, dominated by *O. niloticus* and *C. gariepinus*, has expanded significantly (Munguti *et al.*, 2014). However, common slaughter practices often compromise fish welfare. Methods such as air asphyxiation, ice chilling, and exsanguination without stunning are prevalent despite being deemed inhumane by the World Organisation for Animal Health (OIE, 2017). These methods cause prolonged suffering, reduce meat quality, and hinder market competitiveness. Implementing humane practices, such as electrical stunning, is essential for improving welfare outcomes and meeting international standards (Onyango *et al.*, 2019).

Common slaughter practices in Kenya

Kenyan aquaculture frequently employs traditional fish slaughter methods that pose welfare concerns:

1. Air asphyxiation: This method prolongs fish consciousness, causing considerable distress, particularly in species like *O. niloticus* and *C. gariepinus*, which are highly tolerant to low oxygen conditions (WOAH, 2010). Additionally, it compromises product quality by inducing stress-related biochemical changes.

2. Ice chilling: Although commonly used to immobilise fish, this method fails to induce immediate unconsciousness, resulting in significant suffering before death. Cold-tolerant species such as *O. mykiss* may endure prolonged distress (WOAH, 2010).

3. Exsanguination without stunning: Cutting the gills of conscious fish causes extreme pain and distress, with African catfish reported to remain conscious for over 10 minutes post-incision (HSA, 2018). Cutting only one gill arch further extends the suffering.

4. Manual percussive stunning: This method can be humane if applied correctly; however, poor technique or lack of training may result in incomplete stunning, prolonging suffering (Brijs *et al.*, 2020).

5. Brain Spiking (*Iki Jime*): This method is effective if accurately performed, but requires skill to target the brain precisely. Errors risk prolonged consciousness (WOAH, 2010).

6. Chemical anaesthesia: While potentially humane, concerns over chemical residues in fish tissues raise safety issues for consumers. Certain species, such as *C. gariepinus*, have shown resistance to effective sedation (HSA, 2018).

7. CO_2 Narcosis: Although this method can immobilise fish, it often results in violent reactions and acidic water conditions, increasing distress (WOAH, 2010).

Fish welfare guidelines for certification on slaughter

Regulatory framework and effective stunning practices

Regulations addressing stunning and slaughter must be explicitly stated within the farmed standards to ensure compliance and promote fish welfare:

i. Effective stunning must render fish immediately and fully unconscious (within one second) using scientifically validated methods that maintain unconsciousness until death.
ii. Use recommended humane techniques, including electrical stunning, which reduces pre-slaughter stress, and percussive stunning, which is practical for operators with limited access to electrical equipment (HSA, 2018; HSI, 2018). Inhumane methods, such as ice slurry, CO_2, ammonia baths, and salt for stunning or slaughter, must be explicitly prohibited.
iii. Brain spiking is effective but requires specialised skills, making it less practical for large-scale operations.
iv. Combining stunning methods with immediate exsanguination ensures fish do not regain consciousness post-stunning (Brijs *et al.*, 2020).
v. Assessment and backup methods: Fish should be regularly assessed for signs of consciousness after stunning (e.g. opercula eye movement) by adequately trained personnel. A backup method for stunning and

humanely killing any fish that remain alive and conscious after the initial stunning must be established.

vi. Minimising time and stress: The time between stunning and slaughter should be minimised to reduce the risk of consciousness recovery. Additionally, time spent in crowding and pre-slaughter practices, as well as transportation from the rearing facility to the slaughter facility, should be minimised. Key pre-slaughter strategies include fasting (withholding feed for 24–48 hours to reduce gut content), gradual crowding with sufficient oxygen supply to minimise stress, and gentle handling to maintain fish welfare and product quality (Njoga *et al.*, 2023).

Regulatory and capacity-building recommendations

Kenya's fish industry should align with OIE guidelines by implementing specialised training for personnel on humane methods, recognising signs of consciousness post-stunning, and understanding fish anatomy (Munguti *et al.*, 2014). Relevant bodies, such as the KeFs and county governments' Directorate of Fisheries, should enforce humane slaughter regulations to align with international welfare standards, thereby improving access to export markets. Additionally, producers should invest in electrical stunning technology and ensure routine maintenance of their equipment for optimal performance (HSI, 2018).

MODULE 9: ENVIRONMENTAL ENRICHMENT (EE) AND FISH WELFARE

Introduction to Environmental Enrichment

Environmental enrichment (EE) is a vital intervention in Kenyan aquaculture that enhances fish welfare by promoting species-specific *behaviour*s, reducing stress, and improving overall health. EE strategies are particularly valuable in intensive and semi-intensive systems, where controlled environments often limit natural *behaviour*s.

Fish Welfare Guidelines for Environmental Enrichment and Certification

Regulatory framework and research commitment

Regulations addressing environmental enrichment must be clearly stated within farmed standards to ensure compliance and promote fish welfare. Certification schemes should regularly update these standards based on emerging research on fish *behaviour*al motivations and needs to keep practices relevant and effective (Ojelade *et al.*, 2022; Prah *et al.*, 2024).

Stimulation requirements

- **Physical stimulation:** Fish should be provided with at least one form of physical enrichment, such as interactive submerged materials (e.g. ropes, artificial plants, debris), hiding structures like overhanging covers, or water complexifications including dynamic flow rates and bubble curtains (Näslund and Johnsson, 2014; Ojelade *et al.*, 2022).
- **Psychological stimulation:** Psychological enrichment should include varied illumination patterns suitable in intensity and colour to offer visual diversity, and nutritional delivery systems that prevent adverse *behaviour* like aggression while promoting cognitive choice, for example, submerged dispensing machines or substrates encouraging foraging (Munguti *et al.*, 2021; Prah *et al.*, 2024).

3. Forms of environmental enrichment

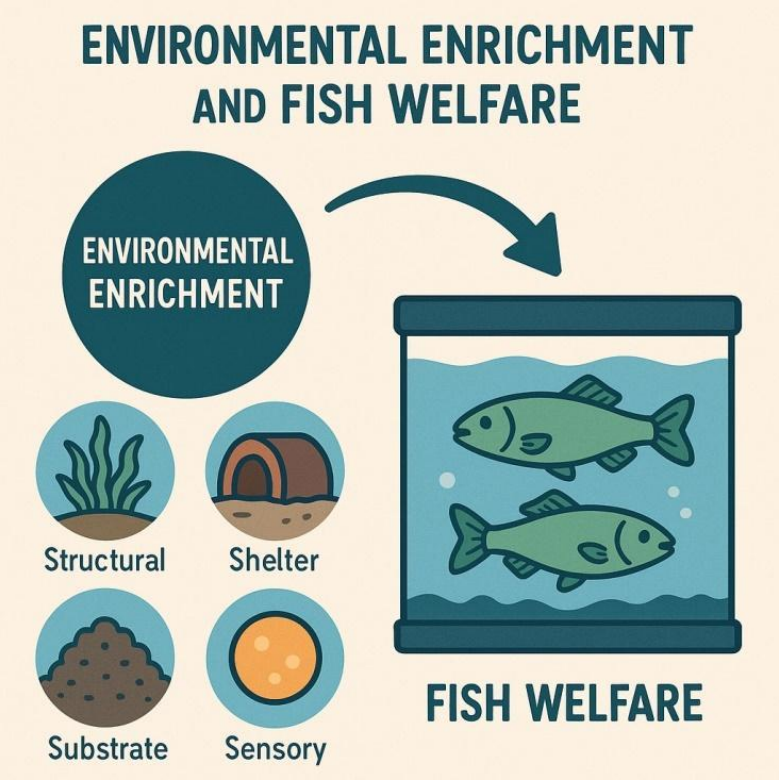

Figure 12 Interaction between environmental enrichment and fish welfare

Structural Enrichment: Physical additions, such as shelters, reduce stress and aggression, especially in species like the African catfish (*Clarias gariepinus*). *Enrichments like sand or gravel substrates encourage natural behaviours (Ojelade et al., 2022; Näslund and Johnsson, 2014)*.

Natural materials: Locally sourced materials improve semi-intensive systems, for example, water hyacinth (*Eichhornia crassipes*) provides shelter and foraging opportunities for tilapia and catfish, while mangrove-friendly systems support milkfish welfare and environmental conservation (Mirera, 2019; Ojelade *et al.*, 2022).

Physiological enrichment: Enriched environments reduce stress indicators (e.g. blood glucose), enhancing immunity and fitness. For rainbow trout (*Oncorhynchus mykiss*), varied flow induced by suspended devices improves swimming *behaviour* and growth (Huysman *et al.*, 2022; Ojelade *et al.*, 2022).

4. Species-Specific Strategies

Tailored enrichment strategies maximise welfare

i. African catfish benefit from dark tank colouration, floating covers, and nocturnal feeding aligned with natural habits (Prah *et al.*, 2024).
ii. Nile tilapia show reduced aggression with plant-fibre ropes stimulating exploration (Munguti *et al.*, 2021).
iii. Common carp (*Cyprinus carpio*) display improved health with substrates like gravel and aquatic plants (Mwangi, 2010).

5. Sustainable Practices and Implementation Considerations

Environmental enrichment supports sustainability. Small-scale farmers utilise food waste and crop residues to improve both nutrition and environmental health (Njagi, 2023). Recirculating Aquaculture Systems (RAS) enable precise control of conditions, thereby improving welfare for species such as African catfish and Nile tilapia (Prah *et al.*, 2024). However, effective implementation requires an understanding of species' needs and the avoidance of overly complicated systems that could cause stress or disease; collaborative research is essential to tailor context-specific solutions (Ojelade *et al.*, 2022).

MODULE 10: ANIMAL HEALTH AND FISH WELFARE

Animal welfare refers to the overall well-being of animals, encompassing humane handling, care, and husbandry practices (Emam *et al.*, 2024). Conversely, animal health focuses on the absence of disease and the normal functioning of an organism (Kyule-Muendo *et al.*, 2022). While these concepts are distinct, they are interdependent; optimal welfare directly supports fish health, and vice versa. Ensuring both aspects are crucial for sustainable aquaculture in Kenya.

In Kenyan aquaculture, key farmed species such as *Oreochromis niloticus* and *Clarias gariepinus* require improved welfare practices to reduce stress, enhance growth, and prevent disease outbreaks. Despite its importance, fish welfare is often overlooked, contributing to increased disease prevalence and reduced productivity (Emam *et al.*, 2024). This oversight highlights the need for integrated welfare and health management strategies that align with sustainable production goals.

Integration of Welfare and Health Practices in Kenyan Aquaculture

Key welfare practices that align with improved fish health include:

- **Humane handling:** Reduces stress and minimises injuries during capture, transportation, and stocking.
- **Feeding practices:** Providing nutritionally balanced diets boosts immunity and promotes fish growth
- **Environmental management:** Ensuring optimal water quality, stocking density, and oxygen levels prevents stress and disease.
- **Health monitoring:** Routine health checks enable early detection of infections, preventing outbreaks.

A comprehensive approach that integrates these welfare-focused practices with disease prevention strategies enhances fish survival, farm productivity, and economic returns.

Biosecurity for Fish Health and Welfare

Biosecurity plays a vital role in safeguarding fish health and promoting welfare. Effective biosecurity protocols minimise pathogen transmission, reduce stress, and improve overall fish resilience (Kyule-Muendo *et al.*, 2022). However, studies in Western Kenya revealed that 76.1% of fish farmers reported mortalities linked to inadequate biosecurity awareness and implementation (Kyule-Muendo *et al.*, 2022). To improve biosecurity in Kenyan aquaculture, the following measures are recommended:

1. Fish stock management: Introducing only healthy fish while ensuring optimal immunity through proper husbandry.

2. Pathogen control: Sanitation, hygiene, and controlled access reduce contamination risks.

3. Human activity management: Training staff and controlling visitor movements minimises disease transmission.

The Kenya Fish Welfare Project has played a crucial role in promoting awareness and enhancing biosecurity measures through training and improved feeding practices (Ethical Seafood Research, 2025). Additionally, a regional aquatic biosecurity strategy has been proposed to address disease risks and promote sustainable aquaculture (WorldFish *et al.*, 2021).

Economic impact of biosecurity in aquaculture

Neglecting biosecurity measures often results in severe financial losses, particularly in intensive aquaculture systems, such as recirculating aquaculture systems (RAS) and hatcheries. A single outbreak can devastate fish stocks, resulting in significant economic strain (WorldFish *et al.*, 2021). Therefore, prevention through biosecurity is far more cost-effective than reactive treatment. Furthermore, compliance with documented biosecurity standards enhances access to international markets, thereby improving economic gains for Kenyan fish farmers (Ethical Seafood Research, 2025).

Key Biosecurity Practices in Kenyan Aquaculture

To mitigate disease risks, Kenyan fish farmers are encouraged to adopt the following practices:

- **Water Quality Management:** Regular monitoring and treatment of incoming water to prevent pathogen entry (FAO, 2020).
- **Stock Movement Control:** Implementing quarantine protocols and restricting fish movement between farms (Cascarano *et al.*, 2021).
- **Farm Access Control:** Enforcing restricted access zones and maintaining hygiene protocols for visitors and workers.
- **Sanitary Measures:** Regular disinfection of equipment, culture systems, and personnel protective gear (World Bank, 2014).
- **Pest and Predator Control:** Preventing interactions with wild fish and potential pathogen carriers.
- **Record Keeping and Surveillance:** Documenting disease occurrences, farm inspections, and biosecurity protocols to enhance preparedness.
- **Proper Feed Management:** Ensuring feed quality and correct storage reduces the risk of contamination (Cascarano *et al.*, 2021).

Implementing these biosecurity measures significantly reduces fish mortalities, enhances welfare, and improves farm profitability.

Fish Diseases and Their Impact on Aquaculture

Fish diseases pose a significant challenge to aquaculture productivity in Kenya, resulting in reduced growth rates, mortality, and financial losses. Fish diseases may occur due to a lack of technical knowledge that impedes effective disease prevention, inadequate training and access to extension services, a lack of biosecurity plans for proper disease prevention and several economic constraints that limit farmers' ability to sustain proper feeding and treatment practices. To address these challenges, coordinated training *programme*s, improved veterinary support, and strengthened biosecurity protocols are essential (World Bank, 2014).

1. Bacterial diseases

Bacterial infections in fish farms often result from poor water quality, overcrowding, and injuries. The most common bacterial diseases include:

Table 4 Common bacterial diseases, symptoms and management

Disease	Causative Agent and risk factor	Symptoms	Management
Red Pest Disease	*Aeromonas* spp., *Pseudomonas* spp.	Bloody streaks on the body, fins, and tail, leading to ulceration and possible fin and tail rot in severe cases.	Improved water quality, reduced stocking density, and antibiotic treatment under veterinary supervision (FAO, 2020).
Mycobacteriosis	*Mycobacterium piscium* Risk Factor: High stocking density in poorly managed ponds.	Emaciation, hollow belly, and skin sores.	Proper farm hygiene, reducing stocking density, and culling infected fish (Mukaila *et al.*, 2023).
Dropsy	*Aeromonas hydrophila*	Severe bloating, protruding scales, and kidney dysfunction leading to fluid accumulation.	Quarantine of infected fish, antibiotic therapy, and maintaining optimal water conditions (Cascarano *et al.*, 2021).
Tail Rot and Fin Rot	*Aeromonas* spp., *Pseudomonas* spp.	Fin disintegration, exposed fin rays, red-edged ulcers, and cloudy eyes.	Maintaining clean water, treating minor injuries promptly, and

			using medicated baths (FAO, 2020).
Bacterial Ulcers	*Haemophilus* spp.	Loss of appetite, lethargy, and ulcerative lesions.	Antibiotic treatment, stress reduction, and improved sanitation (Mukaila *et al.*, 2023).

2. Common fungal diseases in farmed fish

Fungal infections in fish often occur secondary to injuries, poor water quality, or bacterial infections. The most prevalent fungal diseases include:

Table 5 Common fungal diseases, symptoms and management

Disease	Causative Agent	Symptoms	Management
Mouth Fungus	*Chondrococcus columnaris*	White cotton-like patches around the mouth, leading to difficulty eating and potential toxin production.	Salt baths, antifungal treatments, and improved water conditions (Cascarano *et al.*, 2021
Ichthyosporidiosis	*Ichthyosporidium* spp.	Liver and kidney infections, sluggishness, balance loss, and a hollow belly.	Isolation of infected fish and antifungal treatments (FAO, 2020).
Saprolegniasis	*Saprolegnia* spp.	Cotton-like growth on the skin, often following injury or parasitic attack.	Treating underlying infections, improving hygiene, and using potassium

			permanganate dips (Mukaila *et al.*, 2023).

3. Viral diseases

One notable viral disease affecting fish is Lymphocystis, caused by the Lymphocystis disease virus (LCDV) from the Iridoviridae family. This disease manifests as nodular, white swellings resembling cauliflower on the skin, fins, or gills of the fish. While it is infectious, it typically does not result in significant mortalities. The disease has been reported in over 125 different marine and freshwater fish species, including cichlids, which are prevalent in Kenyan aquaculture (Yanong, 2020).

Tumours in fish can arise from viral infections or genetic factors. Genetic tumours are often linked to excessive hybridisation, a practice common among professional breeders aiming to develop specific strains. it is important to note that most tumours in fish are untreatable. If an affected fish shows signs of distress, it is advisable to humanely cull and remove it from the population to prevent further suffering and potential spread of disease.

4. Parasitic diseases

Parasitic infections are widespread in Kenyan aquaculture, leading to irritation, stress, and secondary infections.

Table 6 Common parasitic diseases, symptoms and management

Disease	Causative Agent	Symptoms	Management
Argulosis (Fish Lice Infestation)	*Argulus* spp.	Fish scraping against objects, clamped fins, restlessness, and inflammation.	Chemical treatment with formalin or potassium permanganate, and pond drying (FAO, 2020).

Velvet Disease (Rust Disease)	*Piscinoodinium pillulare*	Yellow-brown "dust" on the body, clamped fins, and respiratory distress.	Copper-based treatments and improved water quality (Cascarano *et al.*, 2021).
Anchor Worm Infestation	*Lernaea* spp.	Thread-like worms protruding from the skin, inflamed attachment points, and excessive scratching.	Manual removal of worms, salt baths, and chemical treatments (Mukaila *et al.*, 2023).
Gill Parasite Infestation (Erasmus Disease)	*Ergasilus* spp.	Scraping against objects, gill irritation, and visible thread-like parasites.	Chemical treatment and improved aeration (FAO, 2020).
Fluke Infestation	*Dactylogyrus* spp., *Gyrodactylus* spp.	Scraping *behaviour*, reddened skin, mucus covering gills, and fin erosion.	Salt and maintaining good water conditions (Cascarano *et al.*, 2021).
Nematode (Threadworm) Infestation	*Camallanus* spp., *Capillaria* spp.	Hollow belly, worms protruding from the anus, and reduced feeding	Anthelmintic treatments and improved sanitation (Mukaila *et al.*, 2023).
Leeches	*Piscicola* spp.	Heart-shaped worms attached to the skin, fins, and gills.	Salt baths and manual removal (FAO, 2020).

5. Protozoan diseases

Protozoan infections can severely impact the health of farmed fish, often leading to mortality in poorly managed systems.

Table 7 Common protozoan diseases, symptoms and management

Disease	Causative Agent	Symptoms	Management
Costiasis	*Ichthyobodo necator*	Milky cloudiness of the skin	Salt bath (Cascarano *et al.*, 2021).
Hexamitiasis	*Hexamita* spp.	Loss of appetite and intestinal inflammation.	Metronidazole treatment and improving nutrition (FAO, 2020).
Ichthyophthiriasis (White Spot Disease)	*Ichthyophthirius multifiliis*	White salt-like specks, excessive slime, and respiratory issues.	Temperature elevation and formalin treatment (Mukaila *et al.*, 2023).
Neon Tetra Disease	*Plistophora hyphessobryconis*	Muscle degeneration and erratic swimming.	Isolation of infected fish and improved farm hygiene (FAO, 2020).
Myxosporidiosis	*Myxobolus* spp.	Cysts on internal tissues, weakness, and scale loss.	Improved biosecurity and pond disinfection (Cascarano *et al.*, 2021).

Disease Management in Aquaculture

Effective fish disease management in Kenya involves a combination of preventive and curative strategies. Key approaches include:

1. Disinfection and hygiene management: Regular cleaning of aquaculture systems using disinfectants such as chlorine, potassium permanganate, and agricultural lime helps reduce pathogen load. Disinfecting equipment, tools, and culture facilities minimises contamination risks and disease outbreaks.

2. Water quality management: Monitoring key parameters such as oxygen levels, pH, and ammonia concentration helps reduce stress and improve fish immunity. Poor water quality exacerbates disease risks (Opiyo *et al.*, 2018).

3. Antimicrobial use: Antibiotics are effective against bacterial infections but must be used judiciously under veterinary supervision to prevent antimicrobial resistance (AMR). Overuse or misuse of antibiotics can lead to the development of resistant pathogens, posing risks to fish health and food safety (Wanja *et al.*, 2020).

4. Alternative treatments: Salt baths, herbal remedies, and medicinal plants are gaining popularity as complementary treatments. While some traditional methods have shown promise, further research is necessary to validate their safety and efficacy.

5. Vaccination: Vaccines are an effective preventive measure where available, reducing reliance on antibiotics and enhancing fish immunity.

6. Biosecurity measures: Implementing strict protocols such as disinfecting equipment, maintaining quarantine procedures, and controlling farm access helps prevent disease outbreaks.

7. Education and training: Empowering farmers with knowledge about disease identification, treatment options, and AMR prevention is crucial for improving fish health management (Fiorella *et al.*, 2023).

Disease Reporting and Antimicrobial Resistance (AMR)

Disease reporting

Accurate and timely disease data is essential for monitoring fish health. Kenyan fish farms are required to keep detailed records of disease outbreaks, treatments, mortality rates, and causes of death to enhance management practices (Fiorella *et al.*, 2023). Prompt reporting of suspected disease outbreaks helps mitigate economic losses and prevent the spread of pathogens (Opiyo *et al.*, 2018).

Antimicrobial resistance (AMR)

AMR arises from the misuse and overuse of antimicrobials, posing risks to fish health, food safety, and ecosystems (Wanja *et al.*, 2020). In Kenya, multidrug-resistant bacteria have been reported in aquaculture systems, highlighting the urgent need for responsible antimicrobial use (Cabello, 2006).

Spread of AMR from aquatic systems to humans

AMR can spread through:

- Food contamination – Antibiotic residues in fish.
- Occupational exposure – Risk to farmers and veterinarians.
- Environmental contamination – Water systems carrying resistance genes.
- Recreational activities – Contact with contaminated water bodies (Towers, 2014).

Environmental impact of AMR: Excessive antibiotic use in aquaculture results in antimicrobial residues contaminating ecosystems, disrupting microbial communities, and threatening biodiversity (Larsson *et al.*, 2018).

Recommendations for managing AMR in Kenyan aquaculture

To address AMR risks, the following measures are recommended:

- **Improved biosecurity:** Enforcing strict protocols to minimise infection risks.
- **Vaccination:** Promoting vaccines as an alternative to antibiotics.
- **Surveillance and monitoring:** Establishing diagnostic labs and tracking AMR patterns (Adekanye *et al.*, 2020).
- **Farmer education:** Providing training on antimicrobial stewardship and disease prevention strategies.
- **Environmental protection:** Ensuring proper disposal of antimicrobial waste to prevent contamination.

Alternative Approaches to Disease Management

- **Probiotics:** Enhance gut health and immunity, reducing antibiotic dependency (Chabrillón *et al.*, 2005).
- **Immunostimulants:** Such as β-1,3 glucans improve fish resistance to bacterial infections (Ngamkala *et al.*, 2010).
- **Bacteriophages:** Serve as biological control agents for bacterial infections, especially when vaccines are unavailable (Castillo *et al.*, 2012).

- **Medicinal plants:** Extracts from plants like neem, turmeric, and peppermint show antibacterial potential against common fish pathogens (Newaj-Fyzul and Austin, 2015).
- **Policy and regulatory compliance:** Kenyan fish farmers must adhere to national regulations on antimicrobial use. Agencies such as the Kenya Fisheries Service (KeFS) and the Pharmacy and Poisons Board (PPB) regulate the use of veterinary drugs in aquaculture. Observing withdrawal periods ensures that fish products meet food safety standards before consumption (WOAH, 2023).

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@afiwelprogram

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afiwelprogram@onehealthdev.org