THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES

GLOBAL ISSUES & LOCAL PERSPECTIVES

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Published By:

Society for Agriculture, Environmental Resources & Management (SAEREM)

SAEREM BOOK CHAPTERS First Published 2025 ISBN 978-978-60709-7-1

First published 2024

SAEREM World

Nigeria

Typeset in Times New Roman

THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES (GLOBAL ISSUES & LOCAL PERSPECTIVES)

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Printed at: SAEREM World

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Preface

THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous ***The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources*** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate change, food security, national security and environmental resources issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.

The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources: Global issues and Local Perspectives is organized in three parts. Part One deals with The Concept of Value Chains in Agriculture, Part Two is concerned with The Concept of Climate Actions and Part Three deals with the Concept of Value Chains and Environmental Resources.

Eteyen Nyong/ Ignatius Onimawo

April 2025

Chapter Two

Sustainable Value Chains in Aquaculture: Leveraging Climate Action and Environmental Resource Management for Resilience and Growth

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1.0 Introduction

Aquaculture according to FAO (2022) can be defined as the artificial rearing of aquatic organisms which includes finfishes (tilapias, catfishes, etc), shellfishes (crustaceans, molluscs, etc) and aquatic plants (seaweeds) in controlled (total enclosure in confinement) or semi- controlled (enclosure in natural environment) culture system such as earthen ponds, raceways, silos, concrete tanks, nets, cages, pens under ambient or controlled environment for fast and qualitative growth for the purpose of consumption, source of revenue, recreation or as ornaments. Aquaculture's input to inclusive fish production globally has unrelenting continue to rise, attaining an estimated value of 46% (about 82.1 million tons) out of the approximated 179 million tons of global production and it is still expected to increase from the current percentage of 46% to a striking value of about 53% in 2030 (FAO, 2020).

Aquaculture is a critical component or contributor of global food security but its growth must be balanced with environmental sustainability and climate resilience. Aquaculture is a rapidly growing industry with significant economic and social benefits. However, its environmental impacts like greenhouse gases emission, habitat destruction and water pollution to the environment and others too numerous to mention are of great concern (World Bank, 2020).

Value chain is a series of processes that can add positive values to a product. It involves all the steps from supplying of raw materials (seeds, feeds, equipment) to designing, production, processing, marketing, distribution, and sales till the product or service gets to the final consumer or discarded after use. Each stage involves multiple stakeholders, including farmers, processors, retailers, and consumers. The value chain is not only a driver of economic growth but also a critical source of employment and nutrition, particularly in developing countries. There is a general agreement that aquacultural production does not occur in isolation rather, it has focal ties / bonds with other food production systems (Troell *et al*., 2021). There is therefore, the need to identify the bonds between wild fisheries, aquaculture and agricultural techniques in order to be able to meet up with the escalating demand for aquatic or seafood products (Blanchard *et al*. (2017). However, the sustainability of these value chains is increasingly threatened by environmental degradation and climate change

Climate change poses great risks to aquaculture due to its ability to alter water temperatures abruptly. These changes can disrupt aquatic ecosystems, leading to reduced productivity, increased disease prevalence, and habitat loss. Small-scale aquaculture systems, which are often less resilient, are particularly vulnerable (Barange *et al*., 2020). The aquaculture value chain identifies areas for improvement and discuss strategies for reducing climate chain effects and enhance climate resistance to harsh or unfavorable weather conditions instigated by climate change (Hambrey & Phillips, 2021). Addressing these challenges requires a holistic approach that integrates climate action into every stage of the value chain.

Climate change and its projected effects is now studied and documented to be a major threat to global food security and its production (quality and quantity) (Barange *et al*., 2020; Cai *et al*., 2020; IPCC, 2021; Soto *et al*., 2021). According to IPCC (2021), climate change denotes the variations observed in the geometric distribution of meteorological conditions of a particular region, or place or globally over an extended period, usually ranging from decades to millions of years which is usually caused or attributed to human activities. Several researchers (Barange *et al*., 2020; and IPCC, 2021) have documented at various times that humans have been established to be the key contributor to climate change and its effects through the use of coal, oil, and gas for energy supplies as well as desertification and forest degradation that releases greenhouse gases (GHGs) into the environment.

Lately, climate change consequences on the sustainability of aquaculture have gained substantial interest owing to the its significant role in global food security, nutrition, and generation of a sustainable means of livelihoods for the fisherfolks in poorer communities (Blanchard *et al*., 2017; Béné *et al*., 2020; FAO, 2020 & 2022). Despite some aspects of uncertainty, several projections show that the entire aquaculture value chain is vulnerable to the effects of climate change (Fleming *et al*., 2014; Bueno & Soto, 2017; Barange *et al*., 2018; Dabbadie *et al*., 2018; Cai *et al*., 2020; Hambrey & Phillips, 2021).

The effects of climate change on aquaculture and mariculture have been extensively studied and reviewed both at regional and global scales (De Silva & Soto, 2009; Yazdi & Shakouri, 2010; Clements & Chopin, 2016; Bueno & Soto, 2017; Klinger *et al*., 2017; Dabbadie *et al*., 2018; Froehlich *et al*., 2020; Galappaththi, *et al*., 2020; Maulu *et al*., 2021). However, it was observed that majority of these documented reports from researchers only highlighted the negative effects of climate change to aquaculture while the positive effects of climate change that are essential for improvement and modification procedures were given little or no projections. A comprehensive study of the effects (both the negative and positive effects) of climate change will inspire producers' awareness which will help to minimize the threats on their production.

In this chapter, the author had delved into the effects (negative and positive) of climate change with respect to productions from the aquaculture sector, their implications to the aquaculture sector's sustainability and also documents some mitigation and adaptation strategies. This chapter also explores the intersection of value chains, climate actions and environmental resources in aquaculture.

The concluding part of this chapter also gave some prospects for future development. This content was borne out of intensive reviews of available literatures related to “Climate change and aquaculture” with an international and/or local context dated back to twenty (20) years. It is however, beyond the aim of this book chapter to provide a comprehensive review of all published literature on the subject matter.

1.1 Features of Contemporary Aquaculture:

a) Sustainability: Recent definitions emphasize sustainable practices to minimize environmental impacts, such as reducing reliance on wild fish for feed, managing waste, and preventing habitat destruction.

b) Innovation: Incorporation of advanced technologies like recirculating aquaculture systems (RAS), artificial intelligence (AI) for monitoring, and genetic improvements for disease resistance and growth efficiency.

c) Climate Resilience: Focus on adapting aquaculture practices to climate change, such as breeding heat-tolerant species and integrating aquaculture with ecosystem restoration (e.g., seaweed farming for carbon sequestration).

d) Diversification: Expansion beyond traditional species to include new organisms like seaweeds and invertebrates, which are increasingly recognized for their nutritional and environmental benefits.

e) Global Food Security: Aquaculture is highlighted as a critical component of global food systems, providing a significant share of the world's seafood and supporting livelihoods in developing countries.

1.2. Objectives of Value Chain in Aquaculture

The objectives of value chain in aquaculture in the context of climate action and environmental resources with a focus on promoting sustainability, resilience, and efficiency while minimizing negative environmental impacts are as follows:

1.2.1. The Objectives for Climate Action

a) Reduce Greenhouse Gas Emissions by optimizing feed efficiency to lower the carbon footprint of aquaculture operations.

b) Transitioning to renewable energy sources (e.g., solar, wind) for powering farms and processing facilities.

c) Develop and adopt climate-resilient species and farming practices to withstand extreme weather events, rising temperatures, and ocean acidification.

d) Promote Carbon Sequestration by integrating aquaculture with ecosystems that capture and store carbon, such as seaweed farming or mangrove restoration.

e) Support Low-Carbon Food Systems by positioning aquaculture as a sustainable alternative to high-emission protein sources like beef and pork.

1.2.2. The Objectives for Environmental Resources

a) Sustainable Resource Use by minimizing the use of wild fish for feed by developing alternative feeds (e.g., plant-based, insect-based, or microbial feeds).
b) Reducing water consumption through efficient recirculating aquaculture systems (RAS) and water recycling.
c) Prevent habitat destruction by avoiding the conversion of sensitive ecosystems (e.g., mangroves, wetlands) into aquaculture sites
d) promoting integrated multi-trophic aquaculture (IMTA) to create balanced ecosystems that recycle nutrients and reduce waste.
e) Manage waste and effluents to prevent water pollution from excess feed, chemicals, and organic matter.
f) Adopt best practices to minimize the use of antibiotics and chemicals.
g) Avoid the introduction of invasive species and genetically modified organisms that could disrupt local ecosystems.
h) Support the conservation of wild fish stocks by reducing pressure on overfished species.

1.2.3. The Objectives for Socioeconomic and Governance:

a) Promote Equity and Inclusion by ensuring small-scale farmers and marginalized communities benefit from sustainable aquaculture practices.
b) Provide access to training, financing, and technology to improve livelihoods.
c) Develop and enforce policies that align aquaculture practices with climate action and environmental sustainability goals.
d) Encourage certification schemes (e.g., ASC, MSC) to promote responsible aquaculture.
e) Invest in research and development for sustainable technologies and practices.
f) Encourage partnerships between governments, private sector, and NGOs to achieve shared goals.

1.2.4. The Objectives for Market and Consumer Engagement:

a) Educate consumers about the environmental and climate benefits of sustainably farmed seafood.
b) Implement systems to track the origin and sustainability of aquaculture products throughout the value chain.

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c) Develop markets for climate-friendly and environmentally sustainable aquaculture products.

By aligning the aquaculture value chain with these objectives, stakeholders can contribute to global climate action, protect environmental resources, and ensure the long-term sustainability of the industry.

2.0 Value Chain Dynamics in Aquaculture: Climate Action and Sustainable Resource Management

The aquaculture industry plays a crucial role in global food security, livelihoods, and economic growth. However, as the industry expands, it faces significant environmental and climate-related challenges. Understanding the value chain in aquaculture is essential for addressing these challenges and promoting sustainability. This chapter explores the concept of the aquaculture value chain, with a focus on climate action and sustainable resource management.

2.1 The Aquaculture Value Chain

The value chain in aquaculture comprises all the activities involved in the production, processing, distribution, and consumption of aquatic products. These activities include input supply, farming, harvesting, processing, marketing, and consumption. Each stage of the value chain presents opportunities and challenges in achieving sustainability and climate resilience.

2.1.1 Components of the Aquaculture Value Chain

a) **Input Supply**: This includes provision of essential inputs such as fish fry or seeds, feed, or feed ingredients, fertilizers, hatcheries, equipment, aquaculture tools and technology. Sustainable sourcing of these inputs is critical for minimizing environmental impact.

b) **Production and Farming**: this Involves activities like breeding, feeding, and managing water quality. Aquaculture farming methods vary from extensive and semi-intensive to intensive systems. The actual farming or cultivation of aquatic organisms in controlled environments (e.g., ponds, cages, tanks, or ocean-based systems) using climate-smart aquaculture practices, such as integrated multi-trophic aquaculture (IMTA) and recirculating aquaculture systems (RAS), enhance sustainability.

c) **Harvesting and Post-Harvest Handling**: This is the process of collecting mature aquatic organisms from the farming system using proper harvesting techniques and tools, efficient cold chain management, and waste reduction strategies to maintain product quality and reduce losses.

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d) **Processing and Value Addition**: This is transforming harvested products into marketable forms (e.g., cleaning, filleting, freezing, canning, or value-added products like smoked fish or fish oil) and ensuring their quality, safety and compliance with regulations and standards. Processing facilities must adopt energy-efficient technologies and sustainable packaging to reduce the carbon footprint of aquaculture products.

e) **Distribution**: Transporting products from farms or processing facilities to markets, retailers, or exporters. Involves logistics, cold chain management, and storage. Sustainable supply chains should incorporate eco-labeling, certification, and fair-trade practices to promote environmentally responsible aquaculture.

f) **Marketing and Sales**: Promoting and selling aquaculture products to consumers, retailers, or wholesalers. Includes branding, packaging, and market research to meet consumer demand.

g) **Consumption**: This is the final stage where products reach consumers, either directly or through restaurants, supermarkets, or other outlets. Educating consumers on sustainable seafood choices drives demand for responsibly farmed aquatic products.

2.2 Importance of Value Chain in Aquaculture

The crucial roles played by Value Chains in Aquaculture are listed below:

- Improved food safety: this helps producers to implement effective food safety controls, reducing the risk of contaminants and ensuring a safe product for consumers
- Increased profitability: by optimizing the value chain processes, aquaculture's profits is increased, thereby reducing spoilage and wastage.
- Improved efficiency: this helps to identify lapses and bottlenecks in any of the value chain processes or activities and allowing for amendable for optimization and cost reduction.
- Increased competitiveness: understanding the value chain enables aquacultural businesses to differentiate themselves from competitors, create unique selling points and capture market share.
- Enhanced quality: fish farmers can ensure consistency in quality of their products by regular monitoring and controlling of each stage of the processes in the value chain.

- Improved sustainability: by analyzing the environment and social impacts of each process in the value chain, fish farmers can easily identify opportunities to harnessed for sustainable improvement.
- Increased transparency and traceability: value chain provide a clear understanding of the production process, enabling transparency and traceability of products.
- Improved coordination and effective collaborations: with the proper use of the processes in the value chain, there will be an increase in effective collaborations and improved coordination.

2.3 Stakeholders in Value Chain Processes

The key players involved in value chain processes in aquaculture are sub-divided into four (4) groups. They are:

A) **Primary Players**:

- ***Producers/Farmers***: they produce aquatic products (e.g., finfish, shellfish); they help to sustain value and safety models of the products; and they also supply products to processors or distributors down the chain.
- ***Processors***: the processors convert raw materials into value-added products (e.g., filleting, canning); they maintain quality and safety standards of products down the line and supply quality processed products to distributors or retailers.
- ***Distributors/Wholesalers***: they buy and sell products to retailers or other distributors; manage logistics & transportation and they also provide market information to producers and processors.
- ***Retailers***: the retailers sell products directly to consumers; provide product information & customer service and they also manage inventory and logistics.

B) Secondary players:

- ***Input Suppliers***: Provide goods and services necessary to facilitate production (e.g., feed, equipment) and ensure quality and safety standards.
- ***Transportation/Logistics Providers***: they help to move products through the value chain; they also keep inventory and logistics.
- ***Financial Institutions***: these licensed institutions deal with financing and other financial services; they also handle risk and provide indemnity opportunities.

- ***Government Agencies***: Regulate and support the industry through policies and programs; Provide market information and research support.

C) **Tertiary players**:

- ***Research Institutions***: they conduct researches and develop new and advance technologies; provide training and capacity-building programs for processors and producers mainly.
- ***Consultants***: Offer proficiency and guidance on best procedures to the producers and processors; Provide market evaluation of the products and strategic planning support.
- ***Certification Bodies:*** Verify and enforces compliance with international and national standards and regulations; they also make available certification and labeling programs.

D) Other stakeholders

- ***Consumers:*** Purchase and consume aquatic products; Provide feedback and influence market demand.
- ***NGOs/Advocacy Groups***: Promote sustainability, social responsibility, and environmental stewardship; Influence policy and market trends.
- ***Local Communities***: Host aquaculture operations and may be impacted by industry activities; Provide labor and services to the industry.

2.4 Importance of Aquaculture Value Chains

i. Generates income and employment for millions of people globally, especially in rural and coastal communities.
ii. Provides a reliable source of protein and nutrients, particularly in developing countries.
iii. When managed responsibly, aquaculture can reduce pressure on wild fish stocks and promote resource efficiency.
iv. Diversifies livelihoods and reduces vulnerability to climate change and market fluctuations.

2.5 Sustainability in Aquaculture Value Chain

Achieving sustainability in the aquaculture value chain requires a holistic approach that considers environmental, social, and economic factors. Strategies include:

i. Introduce a transparent and accountable certification practice to ensure that certification practices are transparent, accountable, and free from corruption.

ii. Executing sustainable supply chain management practices, such as sourcing from certified sustainable suppliers.

iii. Engage in focal discussions with industrial stakeholders, local fisherfolks, communities' members, Non-Governmental Organizations (NGOs), and ruling governments, to promote sustainable aquaculture practices.

iv. Supporting research and development in sustainable aquaculture practices.

3.0 Climate Change on Aquaculture

Climate change poses significant risks to aquaculture, affecting production, supply chains, and market stability. Key climate-related challenges include:

3.1 The Effects of Climate change on aquaculture

The following are the adverse effects of climate change on aquacultural practices:

a) Rising water temperatures and change in water quality can affect the growth and health of aquaculture species as altered precipitation patterns and increased evaporation due to warmer temperatures can impact water availability and quality.

b) Decreased pH levels, rise in sea levels and acidification of the oceans can impact shellfish and other calcium carbonate-based species, making it harder for them to build and maintain their shells and can also lead to coastal degradation and the loss of habitats for aquatic species invariably affecting their reproduction and growth.

c) Climate change related occurrences like extreme weather events or droughts can interrupt the supply of feeds for aquaculture species, leading to its unavailability, higher costs of purchase if available, and potential shortages.

d) Climate change can alter the distribution and prevalence of diseases and parasites by creating enabling breeding environment for the parasites and causative disease organisms which affects aquaculture productivity, animal welfare and increased in mortality which eventually causes economic losses to the farmers.

e) Climate-driven changes in species distribution and abundance can impact aquaculture operations like searching for new locations to continue operations, requiring adaptations in species selection, husbandry practices, and market strategies.

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f) Destruction of infrastructure which can disrupt production or aquaculture activities can occur when extreme climate change activities like flood, droughts, storms, hails, earthquakes, etc. takes place.

g) Activities of climate change may necessitate the implementation of new regulations or standards for aquaculture practices, increased cost of production and affect market access.

3.2 Climate Action Strategies in Aquaculture

Despite the adverse effects of Climate change on aquaculture, there still abound prospects for the aquaculture industry to modernize, acclimatize, and become more resistant to the pressures or after-math of climate aquaculture, thereby reducing the risks associated with climate change, expand the sustainability of aquaculture operations, and support food security. Some of the methods to engage in in order to utilize the presence of climate change or to mitigate the effects of climate change, the aquaculture industry must adopt proactive strategies are:

A) Implementing sustainable aquaculture practices that can reduce environmental impacts and improve resilience to climate change. These practices include:

i. Integrated Multi-Trophic Aquaculture (IMTA): IMTA involves cultivating multiple species together, such as fish, shellfish, and seaweed, to create a balanced ecosystem. This approach can help reduce waste, increase biodiversity, and promote ecosystem services.

ii. Recirculating Aquaculture Systems (RAS): RAS involves reusing water in aquaculture systems, reducing water waste and the risk of disease outbreaks. This approach can also help reduce greenhouse gas emissions and energy consumption.

iii. Offshore Aquaculture: Offshore aquaculture involves locating aquaculture facilities in the open ocean, away from coastal areas. This approach can help reduce the risk of coastal erosion, flooding, and water pollution.

iv. Floating Wetlands: Floating wetlands involve creating artificial wetlands on floating structures, which can help to filter water, reduce waste, and promote biodiversity

v. Floating Cage Systems: Floating cage systems involve using cages that float on the surface of the water, allowing for easier maintenance and reducing the risk of disease outbreaks.

vi. Mangrove-Based Aquaculture: Mangrove-based aquaculture involves integrating aquaculture into mangrove ecosystems, providing natural shelter and habitat for aquatic species.

vii. Aquaponics: Aquaponics involves integrating aquaculture with hydroponics, using waste from aquatic species as nutrients for plants.

viii. Climate-Resilient Species Selection: Selecting species that are resilient to climate change, such as those that can tolerate changes in water temperature and pH, can help reduce the risks associated with climate-related impacts.

ix. Agroforestry-Aquaculture Systems: Agroforestry-aquaculture systems involve integrating trees into aquaculture systems, which can help to reduce soil erosion, increase biodiversity, and promote ecosystem services.

x. Biofloc Technology: Biofloc technology involves using beneficial microorganisms to convert waste into a nutritious feed supplement, reducing waste and the risk of disease outbreaks.

xi. Solar-Powered Aquaculture: Solar-powered aquaculture involves using solar panels to power aquaculture systems, reducing energy consumption and greenhouse gas emissions.

xii. Flood-Resilient Aquaculture: flood-resilient aquaculture involves designing aquaculture facilities to withstand flooding, using techniques such as elevated ponds and flood-resistant materials.

xiii. Early Warning Systems: Early warning systems involve using sensors and monitoring systems to detect changes in water quality and weather patterns, allowing farmers to take action to mitigate the impacts of climate-related events.

B) Selecting species that are more resilient to climate change can help reduce the risks associated with climate-related impacts.

C) Using climate-resilient feed sources can help reduce the impacts of climate change.

D) Implementing eco-labeling and certification schemes can help promote sustainable aquaculture practices and provide a market incentive for producers to adopt climate-resilient practices.

E) Conducting climate risk assessments can help identify potential climate-related hazards and inform the development of climate-resilient aquaculture practices.

F) Supporting climate change research, innovations and development can help identify new technologies and practices that can improve the resilience of aquaculture operations to climate change.

G) Developing climate-resilient aquaculture policies can help provide a supportive framework for the adoption of climate-resilient aquaculture practices.

H) Investing in stronger and durable infrastructure that can withstand the destruction of such infrastructures during climate change outbreaks.

I) Improving water and waste management aquaculture practices.

J) Diversifying into aquaculture production systems or technologies like Artificial Intelligence (AI) and IoT or strategies that are sustainable.

4.0 Environmental Resources in Aquaculture Value Chain

The aquaculture industry relies heavily on environmental resources

a) **Water Resources:** Aquaculture requires significant amounts of water for production, processing, and transportation.
b) **Land Resources:** Aquaculture operations require land for facilities, infrastructure, and feed production.
c) **Feed Resources:** Aquaculture feed production requires significant amounts of raw materials, such as fishmeal and fish oil.
d) **Energy Resources:** Aquaculture operations require energy for pumping, aeration, and other processes.

4.1 Conservation of Environmental Resources in the Aquaculture Value Chain

Strategies to conserve environmental resources in the aquaculture value chain effectively are:

4.1.1 Water Management

1. Water recycling and reuse aquaculture systems to minimize water waste and reduce the demand on freshwater resources.
2. Water conservation methods like low-flowing pumps to reduce evaporations and efficient water use practices.
3. Regularly monitor water quality to detect any changes or pollution.

4.1.2 Feed Management

1. Using artificial feed sources that have been verified as ecologically friendly, such as those that use waste reduction and recycling practices.
2. Implement feeding practices that minimize waste and optimize feed conversion ratios.

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3. Explore alternative feed sources, such as plant-based or insect-based feeds.

4.1.3 Energy Management

1. Use renewable energy sources, such as solar or wind power, to reduce dependence on fossil fuels.

2. Use energy-efficient equipment, such as LED lighting and energy-efficient pumps.

3. Implement energy conservation practices, such as reducing energy consumption during off-peak hours.

4.1.4 Waste Management

1. Execute practices that minimize waste generation, such as reducing feed waste and using waste-reducing technologies.

2. Recycle waste materials, such as using fish waste as fertilizer or feed.

3. Ensure proper waste disposal practices, such as using licensed waste disposal facilities.

4.1.5 Land Management

1. Sustainable land use practices, such as using integrated agriculture-aquaculture systems should be encouraged.

2. Protect and restore habitats, such as mangroves, coral reefs, seagrasses and wetlands, that provide ecosystem services.

3. Soil conservation practices, such as the use of legumes as cover crops.

4.1.6 Biodiversity Conservation

1. Select species that are resilient to climate change and have low environmental impacts.

2. Preserve genetic diversity in cross cultured species to reduce the risk of disease outbreaks and improve resistance to climate change.

4.1.7 Social Sustainability

1. Ensure that hired or paid laborers are considered fairly with reasonable renumeration, and they are provided with safe working conditions.

2. Connect with the local communities to understand their concerns, provide benefits, and promote coexistence.

3. Ensure that business practices are transparent, accountable, and free from corruption.

4. Supply training and capacity-building programs for your workers, farmers, and local communities to improve their skills and knowledge.

5. Create conducive environments where workers, farmers and inhabitants of local communities can channel their grievances with assurance that their concerns and worries are valid and would be addressed effectively.

4.1.8 Economic Sustainability

1. Use cost-effective and efficient production practices to reduce costs and improve profitability.
2. Indulge in the acts of expanding products and markets to reduce reliance on a single market or product.
3. Take risk management practices, such as insurance and hedging, to reduce risks and improve resilience.
4. Empower or be involved financially in researches and development to improve production practices, reduce costs and improve profitability.
5. Ensure that financial practices are transparent, accountable and free from corruption.

5.0 Challenges and Barriers to Sustainable Aquaculture Value Chains

Sustainable aquaculture value chains face numerous challenges and barriers that can hinder their development and effectiveness. Below is an overview of the key challenges and barriers:

a. Environmental Constrains

i. Resource Depletion: Over-reliance on wild fish for fishmeal and fish oil in feed can deplete natural fish stocks, undermining sustainability.
ii. Water Pollution: Effluents from aquaculture, such as excess nutrients, chemicals, and antibiotics, can pollute surrounding ecosystems.
iii. Habitat Destruction: Expansion of aquaculture operations, such as shrimp farming, can lead to the destruction of mangroves and other critical ecosystems.
iv. Disease Outbreaks: High-density farming increases the risk of disease spread, which can devastate stocks and harm wild populations.
v. Climate Change: Rising temperatures, ocean acidification, and extreme weather events threaten aquaculture productivity and species survival.

b. Economic Constrains

i. High Initial Costs: Setting up sustainable aquaculture systems often requires significant upfront investment in technology, infrastructure, and training.
ii. Market Access: Small-scale producers may struggle to access lucrative markets due to lack of certification, quality standards, or distribution networks.
iii. Price Volatility: Fluctuations in feed prices, market demand, and competition can make it difficult for producers to maintain profitability.
iv. Dependence on Imports: Many regions rely on imported feed, equipment, or fingerlings, which increases costs and reduces self-sufficiency.

c. Social Barriers

i. Lack of Awareness and Education: Farmers and stakeholders may lack knowledge about sustainable practices, technologies, and their benefits.
ii. Labor Issues: Poor working conditions, low wages, and lack of skilled labor can hinder the development of sustainable value chains.
iii. Equity and Inclusion: Small-scale producers, women, and marginalized groups often face barriers to participation and benefit-sharing in aquaculture value chains.
iv. Cultural Resistance: Traditional practices and resistance to change can slow the adoption of sustainable methods.

d. Governance and Policy Gaps

i. Weak Regulation: Inadequate or poorly enforced regulations can lead to unsustainable practices, such as overuse of antibiotics or illegal farming in protected areas.
ii. Lack of Coordination: Fragmented governance and lack of collaboration among stakeholders (governments, NGOs, private sector) can hinder progress.
iii. Certification Challenges: While certification schemes (e.g., ASC, MSC) promote sustainability, they can be costly and complex for small-scale producers to obtain.
iv. Policy Gaps: Inconsistent or outdated policies may fail to address emerging issues like climate change or technological advancements.

e. Technological and Infrastructure Challenges

i. Limited Access to Technology: Advanced technologies for sustainable aquaculture (e.g., recirculating systems, precision feeding) may be inaccessible or unaffordable for small-scale producers.
ii. Infrastructure Deficits: Poor transportation, storage, and processing facilities can lead to post-harvest losses and reduced product quality.
iii. Data Gaps: Lack of reliable data on stock levels, environmental impacts, and market trends can hinder decision-making and planning.

f. Market and Consumer Challenges

i. Consumer Awareness: Limited consumer understanding of sustainable aquaculture products can reduce demand for certified or eco-friendly products.
ii. Greenwashing: Misleading claims about sustainability can erode trust in certified products and undermine genuine efforts.
iii. Competition with Wild-Caught Fish: Wild-caught fish often dominate markets, making it harder for sustainable aquaculture products to gain traction.

g. Global and Regional Challenges

i. Trade Barriers: Tariffs, non-tariff barriers, and complex trade regulations can limit access to international markets.
ii. Global Supply Chain Issues: Disruptions in global supply chains (e.g., due to pandemics or geopolitical conflicts) can affect feed availability and market access.
iii. Biodiversity Loss: Unsustainable practices can contribute to the loss of aquatic biodiversity, further threatening ecosystem health.

6.0 Case Studies of Sustainable Aquaculture Practices in Africa

Case studies listed below are examples of successful demonstration of some sustainable aquaculture practices in different regions in Africa. The success of these practices has shown the potential for economically, ecologically and socially friendly aquaculture productions.

1. ***Tilapia farming in Egypt***:

   Egypt has implemented sustainable tilapia farming practices, such as using RAS and reducing water waste.

2. ***Catfish farming in Nigeria***:

Nigeria has implemented sustainable catfish farming practices, such as using integrated agriculture-aquaculture systems.

3. ***Mussel farming in South Africa***:

   South Africa has implemented sustainable mussel farming practices, such as using long-line systems and reducing habitat damage.

7.0 Future Projections for Aquaculture Value Chains

Below are some future directions of sustainable aquaculture value chains:

A) Technology and Innovation

1. Widespread adoption of Recirculating Aquaculture Systems (RAS) to reduce water waste and improve water quality.

2. Integration of digital technologies, such as Internet of things (IoT), Artificial Intelligence (AI), and blockchain to improve efficiency, transparency, and sustainability.

3. Development of genetically improved species that are more resilient to disease and climate change.

B) Sustainable Feed and Nutrition

1. Increased use of alternative feed sources, such as insect meal, algae, and plant-based feeds.

2. Development of feed formulations that reduce waste and improve nutrient utilization.

3. Implementation of nutrient recycling technologies to reduce waste and improve water quality.

C) Climate Change Mitigation and Adaptation

1. Development of climate-resilient species that can tolerate changing water temperatures and chemistry.

2. Implementation of climate-smart aquaculture practices, such as using shade, reducing water depth, and improving water circulation.

3. Exploration of aquaculture's potential to sequester carbon and reduce greenhouse gas emissions.

D) Social Responsibility and Human Rights

1. Implementation of fair labor practices, including fair wages, safe working conditions, and social protection.

2. Increased engagement with local communities to ensure that aquaculture operations are socially responsible and beneficial.

3. Implementation of human rights due diligence to identify and mitigate human rights risks.

E) Certification and Labeling

1. Sustainability certification*: Increased adoption of sustainability certification schemes.
2. Increased use of eco-labeling schemes to promote sustainable seafood.
3. Improved transparency and traceability throughout the supply chain.

F) Policy and Regulation

1. Development of policies that promote sustainable aquaculture practices.
2. Strengthening of regulatory frameworks to ensure that aquaculture operations are environmentally and socially responsible.
3. Increased international cooperation to address global challenges and promote sustainable aquaculture practices.

G) Global Goals: Sustainable aquaculture aligns with global goals like the UN Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 2 (Zero Hunger).

6.1 Conclusion

Climate change poses substantial challenges to the aquaculture sector, but it also presents opportunities for innovation, adaptation, and resilience. By understanding the impacts of climate change on aquaculture and implementing climate-resilient practices, the industry can reduce its vulnerability to climate-related hazards and improve its overall sustainability.

Environmental resources are critical to the aquaculture value chain, and their management, conservation, and sustainability are essential for reducing environmental impacts and promoting long-term viability. By implementing these best practices, aquaculture value chains can improve their environmental and social sustainability, reduce their impacts, and promote a more sustainable food system.

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