ASSESSING AND STRENGTHENING COLD CHAIN INFRASTRUCTURE FOR SMALL-SCALE AQUACULTURE IN ZAMBIA

WORLD BANK GROUP

JUNE 1, 2026

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| OJH AquaVeritas Lab and Consultancy

ACRONYMS AND ABBREVIATIONS

IFFFC	Individual Fish Farmers and Farmer Cooperatives
MFL	Ministry of Fisheries and Livestock
ZAEDP	Zambia Aquaculture Enterprise Development Project
CEEC	Citizen Economic Empowerment Commission
ZABS	Zambia Bureau of Standards
ZCSA	Zambia Compulsory Standards Agency
ZAMSTAT	Zambia Statistical Agency
ZDA	Zambia Development Agency
LGA	Local Government Authorities (District Councils)
CBU	Copperbelt University
KMU	Kapasa Makasa University
PU	Palabana University
NRDC	Natural Resources Development College
KFTI	Kasaka Fisheries Training Institute

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Definition of key terms

Term	Definition
Aquaculture	Farming of aquatic organisms such as fish under controlled or semi controlled conditions.
Small-scale aquaculture	Fish farming systems with low input use, small production units, and mainly local market orientation.
Fish value chain	The full sequence of activities from production, harvesting, processing, distribution, to the consumption of fish.
Value chain actors	Stakeholders involved in the fish value chain including producers, traders, processors, retailers, and transporters.
Offtakers	Businesses or individuals who purchase fish from producers for resale, processing, or distribution.
Small-scale business	Enterprises with limited capital, low volumes, and local or district-level market reach.
Medium-scale business	Enterprises with higher operational capacity, larger volumes, and wider market reach.
Cold chain	A temperature-controlled system is used to maintain fish quality from harvest to consumption.
Cold-chain infrastructure	Facilities and equipment used to preserve fish under low temperatures, including ice boxes, freezers, and cold rooms.
Ice box	A portable container using ice for short-term preservation of fish.
Walk in cold room	A refrigerated storage facility for bulk storage of perishable products.
Spoilage	Physical, chemical, or biological deterioration of fish that reduces quality and safety.
Post-harvest losses	Losses in quantity or quality of fish occurring after harvest due to handling, storage, or transport issues.
Shelf life	The period during which fish remains safe and suitable for consumption or sale.
Food safety	Practices ensuring fish is safe for consumption and free from contamination.

Term	Definition
Food safety regulations	Standards and rules governing handling, storage, and sale of fish products.
Business model	The way businesses organize investment and operations, including ownership or collaboration structures.
Partnerships	Collaborative arrangements between stakeholders to share resources or infrastructure.

PURPOSE OF THE ASSIGNMENT

The Zambia Agribusiness and Trade Project II (ZATP II, 2024–2028), supported by the World Bank PROBLUE Multi-Donor Trust Fund promotes the growth, competitiveness and sustainability of Zambia's aquaculture sector. Aquaculture is a strategic sector for improving food and nutrition security, creating jobs, diversifying rural livelihoods, increasing domestic fish supply and strengthening market participation.

The purpose of this assignment was to assess cold chain infrastructure across Zambia's aquaculture value chain, focusing on producers, processors, traders, transporters, wholesalers, retailers, offtakers and institutional stakeholders. The study assessed the availability, affordability, use, and reliability of cold chain infrastructure, including ice boxes, freezers, cold rooms, refrigerated transport, processing facilities and energy systems.

The report identifies key constraints affecting post-harvest performance, including limited access to cold storage, high equipment costs, unreliable energy supply, weak transport and logistics systems, limited financing, regulatory challenges and climate-related pressures. These constraints reduce storage duration, increase spoilage risks, affect fish quality and food safety, and limit market access for small and medium-scale operators.

The report provides practical recommendations to expand and diversify cold chain infrastructure, improve access to affordable and tailored financing, promote shared facilities and cooperative models, strengthen training and business advisory services, and improve energy reliability and climate resilience. These measures are intended to reduce post-harvest losses, improve product quality, enhance food safety and strengthen the resilience and competitiveness of Zambia's aquaculture value chain.

The study was conducted by Mr Oliver J. Hasimuna, Consultant, with support from Mr. Malambo Muloongo, Research Assistant, under the supervision of Mr. Jean Arlet and Yurani Arias Granada, task team leaders for the World Bank PROBLUE Aquaculture Project. Mr. Shane Sela and Mr. Henry Sichembe also provided valuable technical comments and guidance.

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EXECUTIVE SUMMARY

This study provides a comprehensive assessment of cold chain management across Zambia's aquaculture value chain, incorporating insights from producers, downstream actors, and institutional stakeholders. Small and medium-scale operators dominate production and marketing, with pond-based systems leading production and private butcheries, fishmongers, processors, transporters, wholesalers, and retailers facilitating distribution, collectively shaping fish quality, market access, and income stability. Access to cold chain infrastructure remains a critical determinant of post-harvest performance. While basic solutions such as ice boxes and small freezers are widely used, advanced facilities, including walk-in cold rooms, refrigerated transport, and reliable energy systems, remain limited, resulting in short storage durations and rapid turnover. Although knowledge of spoilage, food safety, and quality is generally high, the main constraints relate to infrastructure gaps, affordability, and lack of continuity, compounded by reliance on third party logistics and retail networks.

Financial, operational, and institutional factors continue to influence cold chain investment and management, including high equipment costs, limited access to financing, unreliable energy supply, regulatory challenges, and climate-related pressures. Institutions and universities provide training, research, and advisory support, although direct investment and coordinated infrastructure development remain limited. Encouragingly, stakeholders demonstrate a strong willingness to engage in cooperative arrangements, shared infrastructure, and regional cold chain networks, alongside a clear preference for blended approaches that combine private investment, financial support, training, and partnerships.

To address these gaps, the study highlights the following priority recommendations: expand and diversify cold chain infrastructure; improve access to affordable and tailored financing; promote cooperative, partnership-based, and network models; strengthen training, extension, and business advisory services; and improve energy reliability and climate resilience.

Addressing these priorities across the full cold chain from harvest to market is essential to maintain fish quality, ensure food safety, and enhance marketability. Coordinated development of infrastructure, financing, capacity, and institutional collaboration will strengthen post-harvest efficiency, improve market participation, and increase the resilience of Zambia's aquaculture sector.

1 BACKGROUND

Small-scale aquaculture plays a vital role in Zambia's food system, contributing significantly to employment, income generation, and nutritional security, particularly within rural and peri-urban communities (FAO, 2018; Maulu et al., 2020). Despite its growing importance, the sector remains constrained by limited access to modern post-harvest technologies. A major challenge is the lack of cold chain infrastructure, which is critical for preserving the quality and safety of harvested fish from the point of production to market (Kaminski et al., 2020; Selamoglu, 2021).

Currently, many smallholder fish farmers depend on traditional preservation methods such as open-air sun drying and smoking. While these practices offer temporary solutions, they are insufficient in maintaining product quality or meeting food safety standards, especially for markets that demand fresh or chilled fish (Mramba and Mkude, 2022; Abdul et al., 2024). Without proper cold storage and transport systems, fish products are highly susceptible to spoilage, leading to substantial post-harvest losses, reduced shelf life, and decreased profitability (Lailossa, 2015; Maulu et al., 2020).

The challenges related to cold chain infrastructure are particularly pronounced among small-scale producers who face constraints such as unreliable electricity, high operating costs, poor road network, unreliable land and water transport, and limited technical expertise (Grema et al., 2020; Maulu et al., 2020; Kumar et al., 2023). Maulu et al. (2020) estimate more than 10% of fish harvested in Siavonga District are lost due to inadequate preservation. Similar trends are reported across Sub-Saharan Africa, where about 39% of post-harvest losses occur during production and 36% during handling, largely due to infrastructure gaps (Abelti and Teka, 2024).

Gender disparities also exacerbate the problem, as women who predominantly handle fish processing and marketing are disproportionately affected by limited access to preservation technologies and post-harvest resources. Kaminski et al. (2020) highlight how these structural inequalities reduce women's earnings, hinder their capacity to maintain fish quality, and restrict their participation in more lucrative market segments. Addressing cold chain deficiencies with a gender-sensitive approach can significantly enhance social inclusion and economic equity in the aquaculture value chain.

Although Zambia's aquaculture sector has shown commendable growth by rising to over 75,000 tonnes by 2022 and becoming the largest in the SADC region (Cai et al., 2022; Zhang

et al., 2024), this expansion has largely been driven by commercial producers who culture the exotic *Oreochromis niloticus* (Tran et al., 2018; Hasimuna et al., 2019), while small-scale actors who culture native fish species continue to face significant bottlenecks. Notably, post-harvest losses remain a critical impediment to improved market access and value retention, particularly for indigenous species such as *Oreochromis andersonii*, *Oreochromis macrochir*, and *Coptodon rendalli*. These losses are largely attributed to the limited resources and inadequate access to cold chain infrastructure among small-scale producers who primarily culture these native species, thereby constraining their market potential.

This study, supported by the PROBLUE multi-donor trust-fund (World Bank executed), and informing the broader Zambia Agribusiness and Trade Project II (ZATP-II), assessed and strengthened cold chain infrastructure for small-scale aquaculture in Zambia. By engaging smallholder producers, government agencies, and private sector actors, the research identified infrastructural gaps, improved post-harvest handling practices, and informed practical interventions that reduced losses, improved product quality, and enhanced the competitiveness of Zambia's aquaculture sector.

1.1 Objective

To assess the cold chain infrastructure available to small-scale and medium-scale fish farmers in Zambia, identify key challenges, and explore practical solutions to improve fish storage, processing, and distribution to support market access, reduce post-harvest losses and the development of a resilient aquaculture value chain.

1.1.1 Specific Objectives / Tasks

i. To identify existing cold chain infrastructure used by small-scale fish farmers, including ice-making facilities, refrigeration units, storage hubs, and transportation networks.
ii. To investigate the characteristics of small-scale aquaculture in Zambia and map their geographic distribution and production levels.
iii. To assess the availability, accessibility, and affordability of cold chain infrastructure for smallholders.
iv. To evaluate the impact of inadequate cold storage on post-harvest losses, fish quality, food safety, and overall profitability.
v. To review current models of cold storage facilities, including private vertically integrated systems, third-party logistics, cooperatives, public-private partnerships

(PPPs), and micro-storage units, and determine which models show the greatest adoption and potential for scaling.

vi. To examine government policies, extension services, and training systems related to cold chain management, highlighting gaps and opportunities for improved implementation

vii. To recommend cost-effective, scalable, and sustainable cold chain solutions that can be adopted by small-scale fish farmers and integrated into the wider aquaculture value chain.

2 RESEARCH APPROACH AND METHODS

A mixed methods research design was employed to achieve the study objectives, integrating both primary and secondary data sources. This approach enabled a comprehensive assessment of the cold chain infrastructure landscape for small-scale aquaculture enterprises in Zambia, particularly those producing indigenous and locally available tilapia and non-tilapia species.

Primary data were collected through field visits, structured questionnaires, and key stakeholder consultations, generating insights into post-harvest handling practices, cold chain infrastructure, and operational challenges. Secondary data were used to complement and contextualise the findings. Detailed information on research instruments, sampling procedures, data collection protocols, and analytical methods is provided in Annex Section 1.

3 Project findings

3.1 Sector profile and production structure

The aquaculture value chain is dominated by experienced operators, with more than half of respondents (56.2%) above 40 years of age, and the largest single group being above 50 years (Fig. 1). This indicates that the sector is largely experience-driven but may face slower adoption of new technologies, particularly in cold chain systems, without targeted capacity building. The relatively low participation of youth highlights a structural gap in innovation and long-term sector renewal.

Gender representation is almost equal, with males (50.4%) and females (49.6%) participating in aquaculture activities (see Annex Figure 1). This reflects the important role of women, particularly in fish trading and post-harvest handling, where cold chain systems are most

critical. This balance creates an opportunity for gender responsive cold chain investments and training programmes.

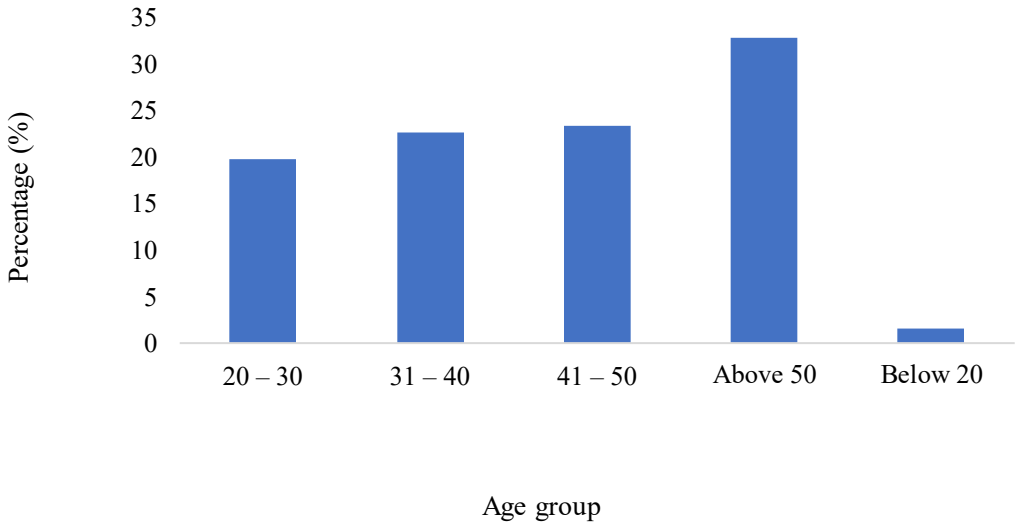

Figure 1: Age groups of respondents

3.2 Production systems: predominantly small-scale pond-based with limited diversification

Aquaculture production is overwhelmingly pond-based (79.6%), reflecting low capital requirements and accessibility for smallholders (Fig. 3). However, a minority of farmers operate multiple systems such as cages, tanks, and integrated fish farming.

This diversification increases variability in harvest timing and volumes, creating a stronger need for flexible and responsive cold chain systems to manage fluctuating post-harvest handling requirements.

Figure 2: *Example of a pond used in fish farming operations*

The presence of multiple production systems among some operators has important implications for cold chain facility requirements, as diversified production may result in varying harvest times, volumes, and handling needs. Consequently, this increases the demand for efficient post-harvest handling, cold storage, and transportation systems to maintain fish quality, ensure food safety, and minimize post-harvest losses across different production systems.

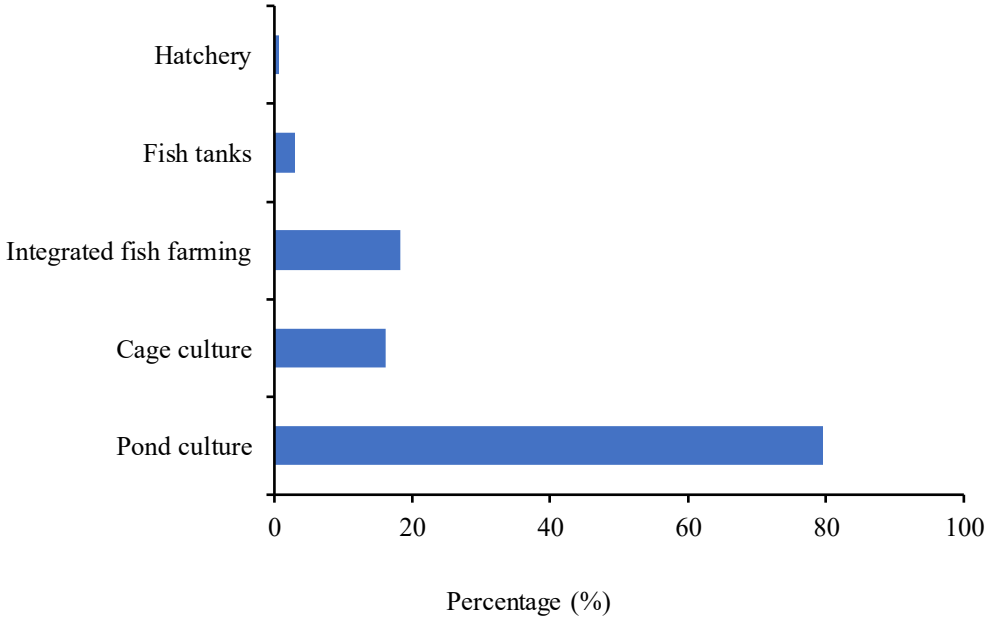

Figure 3: *Aquaculture production facilities*

3.3 Very limited access to cold chain infrastructure

Access to cold storage is extremely limited, with 81.8% of respondents reporting no access to any form of cold storage facility (See Annex Fig. 3). Figure 4 illustrates that where cold storage exists, it is largely restricted to small-scale solutions such as household freezers and ice boxes. As a result, 73% of farmers sell fish immediately after harvest, limiting their ability to store products, manage supply, or access higher-value markets. This reflects a highly time-sensitive market structure in which farmers have minimal control over pricing and market timing.

As a follow-up to access to cold storage facilities, respondents were asked to indicate the type of cold storage they used. The results revealed that the majority of respondents (82.5%, n = 113) did not respond to this question, reflecting those who had earlier indicated no access to cold storage facilities.

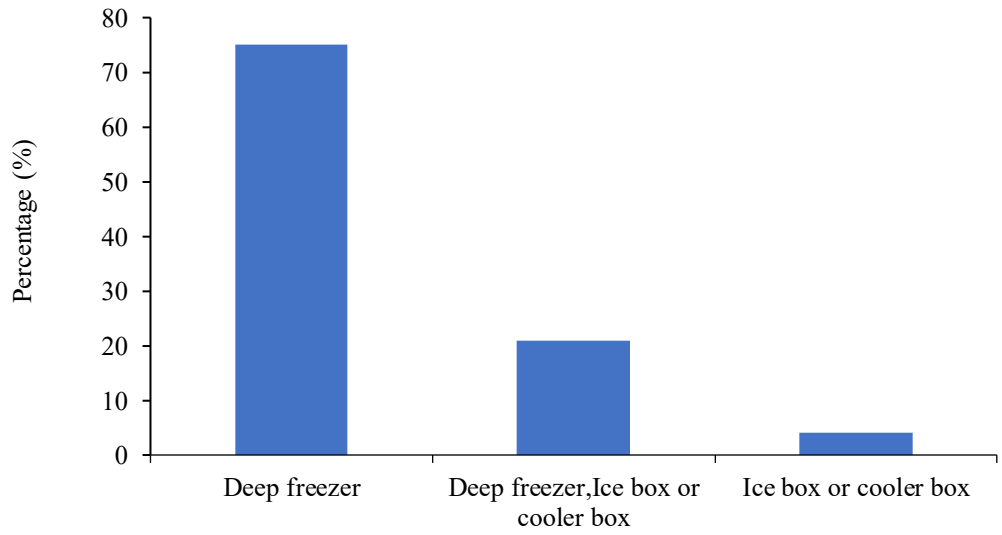

Figure 4: Type of cold storage they used

The limited use of more diverse or advanced cold storage options highlights constraints in cold chain infrastructure among small- and medium-scale aquaculture operators, with potential implications for fish preservation, quality maintenance, and market access (see detailed preservation methods in Annex Fig. 2). This situation may disproportionately affect women and small traders who are heavily involved in post-harvest handling and fish marketing, thereby reinforcing existing gender and income inequalities within the aquaculture value chain. Furthermore, the lack of scalable and shared cold storage facilities points to the need for cooperative-based, mobile, or community-level cold storage solutions that can serve multiple producers efficiently.

Figure 5: An example of freezers used as cold facilities

3.4 High post-harvest losses driven by weak cold chain and transport systems

Post-harvest losses are widespread across the sector, affecting more than 80% of farmers. Nearly half of the respondents reported losses ranging between 10–30% of production, while a significant proportion experienced losses exceeding 30%. Figure 6 shows the distribution of losses among respondents.

As highlighted in Table 1, these losses are strongly linked to:

- lack of refrigeration and cold storage
- unreliable electricity supply
- poor transport systems and long distances to markets
- minimal access to refrigerated logistics

As a result, fish quality deteriorates rapidly, reducing market value and farmer income. Transport systems are largely informal, with reliance on personal and hired vehicles, and very limited refrigerated transport (see Annex Fig. 4). This directly affects fish quality and market value.

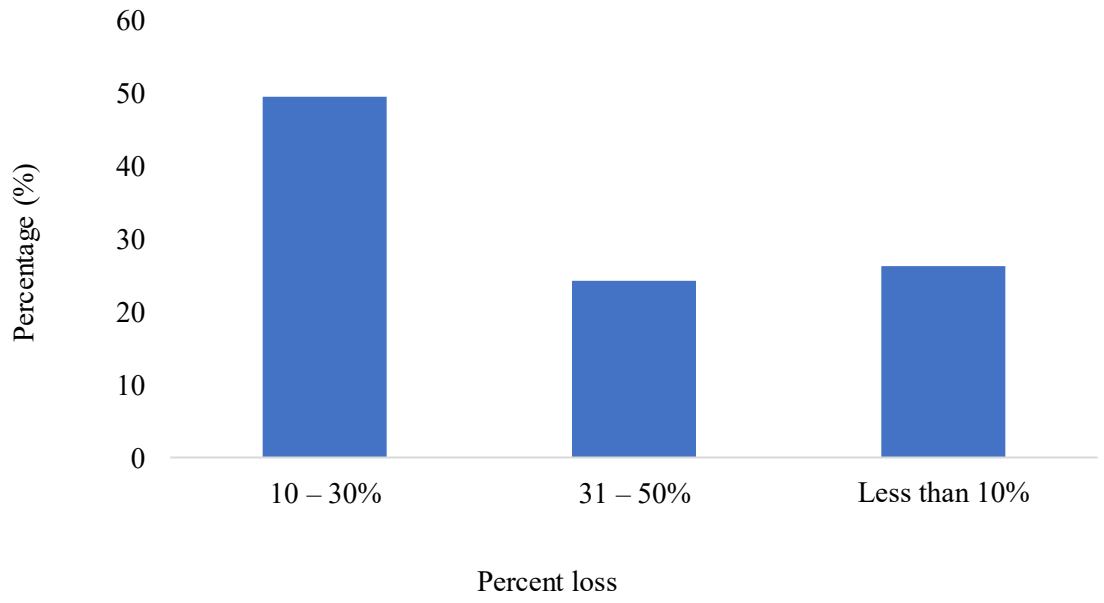

Figure 6: The percentage range of your fish production is lost

Table 1: Challenges related to cold-storage faced and their severity

Challenge	None (%)	Minor (%)	Moderate (%)	Serious (%)	Very Serious (%)	Total (%)
Lack of refrigeration facilities	5.1	3.6	13.1	27.7	49.6	100
High cost of cold storage	3.6	5.1	7.3	33.6	48.2	100
Unreliable electricity supply	2.2	2.9	9.5	27.7	57.6	100
Limited access to ice or frozen storage	2.9	5.1	13.1	24.8	54.0	100

Additional challenges reported by the farmers included transportation, marketing/ income generation, lack of information/knowledge or capacity building, limited funds, water

challenges, and environmental challenges, which affected about 12 of the respondents, representing approximately 9% of all the respondents.

3.5 Cold chain constraints are severe, systemic, and interlinked

Cold chain challenges are widespread and mutually reinforcing. The most severe constraints reported by farmers include:

- unreliable electricity supply
- limited access to ice or frozen storage
- lack of refrigeration facilities
- high cost of cold storage

Table 1 shows that the majority of respondents rated these challenges as serious or very serious, with unreliable electricity emerging as the most critical constraint.

In addition to storage limitations, transport-related challenges further exacerbate losses. These include a lack of refrigerated transport, inadequate cooling during transit, high transportation costs, and spoilage from heat exposure. A large proportion of farmers experience serious to very serious challenges related to transport, including spoilage, delays, and climate-related heat stress (Table 2). Together, these findings indicate that cold chain constraints are systemic, spanning storage, energy, and logistics systems.

3.6 Production-related challenges

Table 2: Production-related challenges

Challenge	None (%)	Minor (%)	Moderate (%)	Serious (%)	Very Serious (%)
High transportation costs	1.5	4.4	12.4	37.2	43.1
Poor road infrastructure	7.3	11.7	16.8	32.1	30.7
Long distances to markets	8.8	14.6	19.7	27.0	29.2
Lack of access to refrigerated transport	2.9	3.6	10.9	32.1	50.4

Challenge	None (%)	Minor (%)	Moderate (%)	Serious (%)	Very Serious (%)
Inadequate cooling during transport	2.2	4.4	12.4	39.4	40.1
Spoilage due to heat during transport	3.6	4.4	8.8	27.7	54.7
Delays are causing loss of freshness	3.6	6.6	13.1	29.2	46.7
Climate change impacts (extreme heat)	2.2	4.4	13.1	29.9	50.4
Understanding causes of fish spoilage	6.6	8.8	16.8	24.1	43.1
Understanding temperature effects on quality	10.9	5.1	12.4	33.6	36.5
Understanding food safety practices	12.4	10.2	24.1	27.0	24.1

3.7 Knowledge exists, but system capacity and compliance remain weak

While most farmers report some exposure to post-harvest training, gaps remain in coverage, consistency, and depth of technical support (Fig. 7). Government extension services remain the dominant source of training. However, awareness of formal food safety standards is low, and even where awareness exists, actual adoption is inconsistent. Certification levels are also low, limiting market access and competitiveness.

Institutional support systems such as cooperatives are weak, with most farmers not belonging to groups and many areas lacking active farmer associations. This reduces access to collective infrastructure, financing, and knowledge sharing.

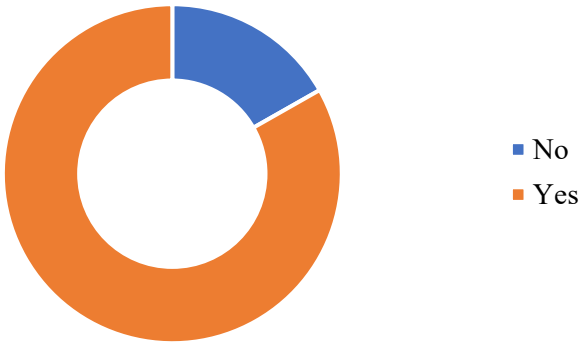

Figure 7: Post-harvest losses are experienced because of inadequate cold storage or transportation

3.8 Training on post-harvest handling: uneven reach but strong dependence on public and project support

Among respondents, 64.2% reported having received training in post-harvest handling, while 35.8% had not (see Annex Fig. 5). Although this indicates relatively broad exposure, the sizeable untrained group suggests continued gaps that may contribute to post-harvest losses and reduced fish quality.

Among those trained, the study found that government extension services are the main providers (50.4%), followed by NGOs or donor-funded projects (18.2%), farmer cooperatives (13.1%), and universities (12.4%) (Fig. 8). The private sector accounts for 10.9%, while only small proportions report training from the World Bank Group (3.6%), ZAEDP (1.5%), ZATP (0.7%), and CEEC (0.7%) (Fig. 3.13). These findings suggest that post-harvest training is largely driven by public extension and externally funded initiatives, with less consistent involvement from the private sector and institutionalised systems. This reliance on project-based delivery may limit continuity and scalability of training, contributing to uneven capacity across farmers. Strengthening coordinated, sustained, and inclusive training systems will be critical to improving post-harvest practices and reducing losses across the value chain.

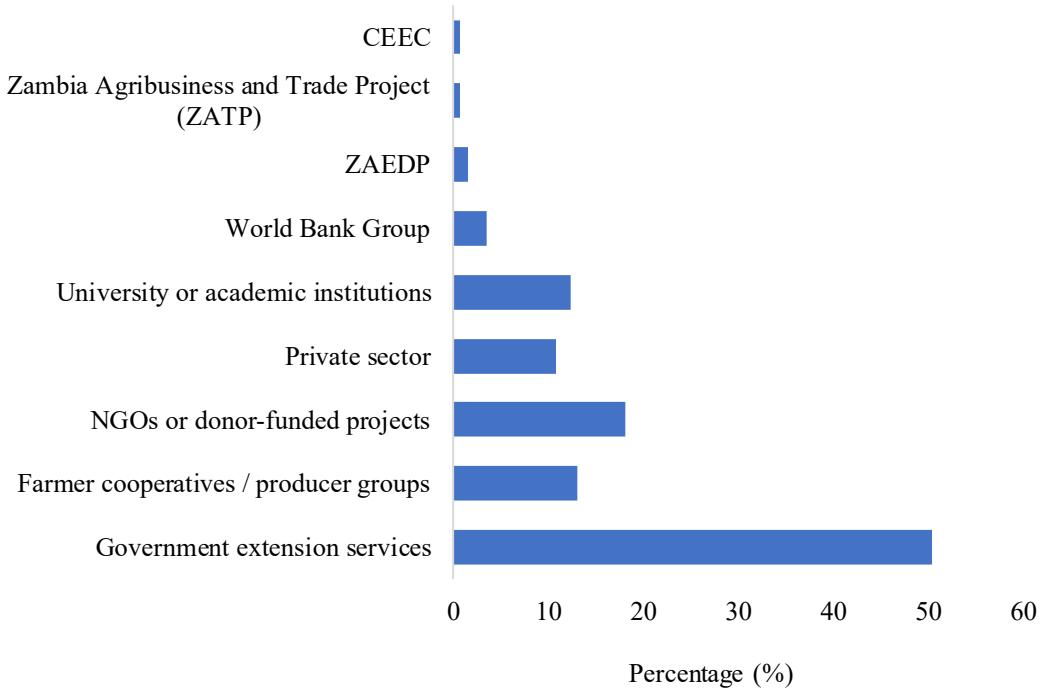

Figure 8: Sources of Post-Harvest Handling Training Among Fish Farmers

Among respondents without prior training, 69.3% were unsure about participating in programmes on fish storage, cold chain management, and post-harvest loss reduction, while 30.7% expressed interest (Fig. 9). This indicates high uncertainty, likely due to limited awareness, perceived relevance, or accessibility of training. However, the presence of an interested minority suggests latent demand. These findings underscore the need for targeted awareness and outreach to improve participation and enhance post-harvest practices.

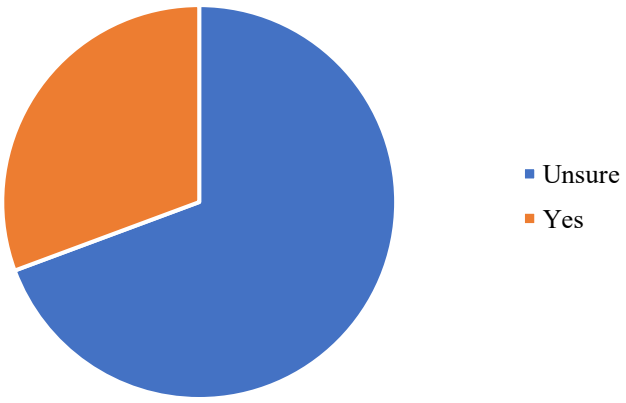

Figure 9: Willingness of Untrained Fish Farmers to Participate in Post-Harvest Training

3.9 Low overall knowledge of safety standards with limited recognition of formal certification systems

Respondents' awareness of food safety and quality standards was generally low. Most (60.3%) were unaware of any standards (Fig. 10). Among those aware, 39.1% recognized Best Aquaculture Practices (BAP), followed by 21.8% for HACCP and 18.7% for Global G.A.P., while only 15.4% were aware of local or national standards. Overall, awareness beyond BAP remains limited, highlighting the need for targeted training, extension services, and policy support to improve knowledge, compliance, and consumer confidence in fish products.

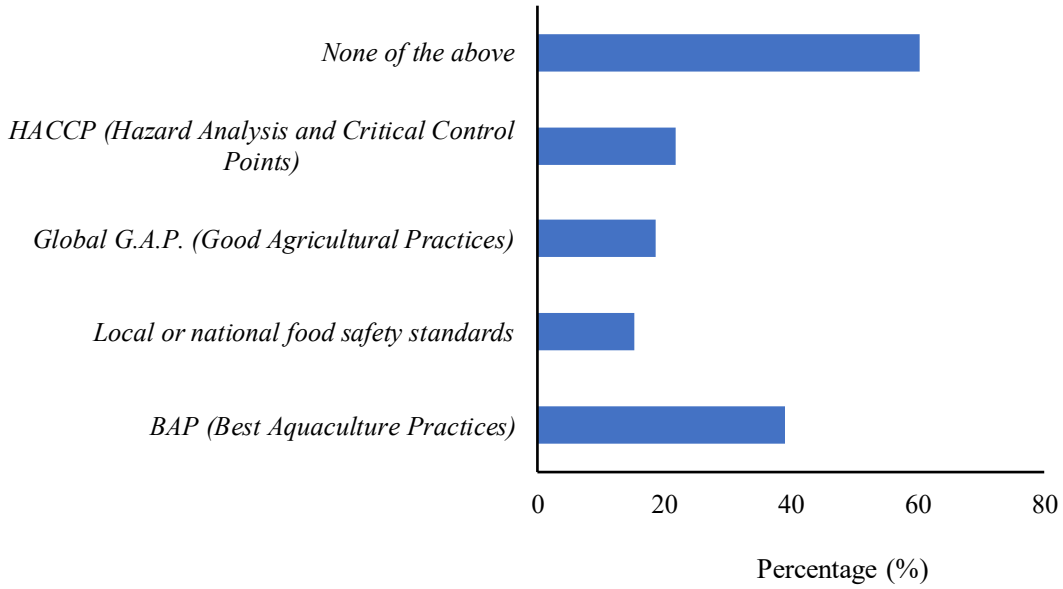

Figure 11: Respondents' awareness of food safety and quality standards in fish farming

3.9.1 Strong willingness for collective action, but limited enabling systems

Despite infrastructure and capacity gaps, there is a strong willingness to adopt collective solutions (Fig. 12). Most farmers express interest in cooperative cold storage, shared transport systems, and regional cold chain networks.

Preferred investment models are mixed, with private ownership still dominant, but significant interest in cooperative and joint investment models. This indicates a strong latent demand for shared infrastructure and collaborative business models.

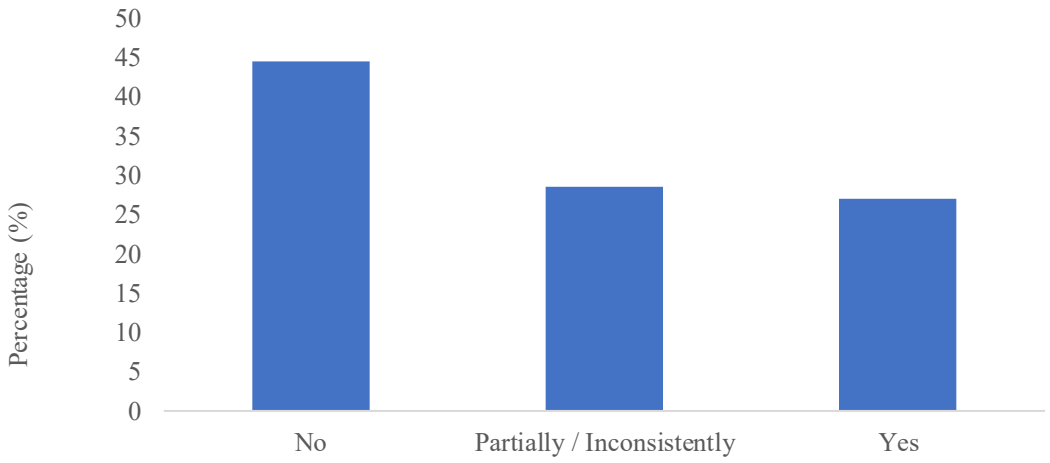

Figure 12: Farm-Level Adoption of Food Safety and Quality Standards

3.10 Core policy message: a system constrained by infrastructure, energy, and coordination gaps

The evidence shows that Zambia's aquaculture sector is productive but structurally constrained in its post-harvest system. The main binding constraints are:

- lack of cold chain infrastructure
- unreliable electricity supply
- weak transport systems
- limited access to finance
- low institutional coordination and weak cooperatives

However, the sector also shows strong readiness for transformation through cooperative models, shared infrastructure, and targeted investment support.

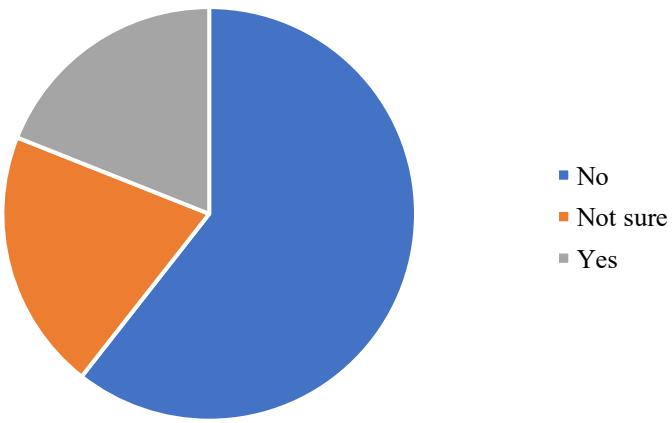

Figure 13: Certification status of fish farms for food safety and aquaculture production.

Farmer Organization and Collective Action: Low Structure, High Willingness

3.11 Weak cooperative presence limits access to markets and services

Cooperative membership among fish farmers remains relatively low, with 56.9% not belonging to any farmer group, while only 42.3% report active membership (Fig. 14). This is further reinforced by the limited presence of cooperatives, as 76.6% of respondents report no active farmer organizations in their area.

This weak institutional landscape constrains farmers' ability to access shared resources, technical support, financing, and organized markets. It also limits opportunities for collective bargaining and investment in shared infrastructure such as cold storage and transport systems.

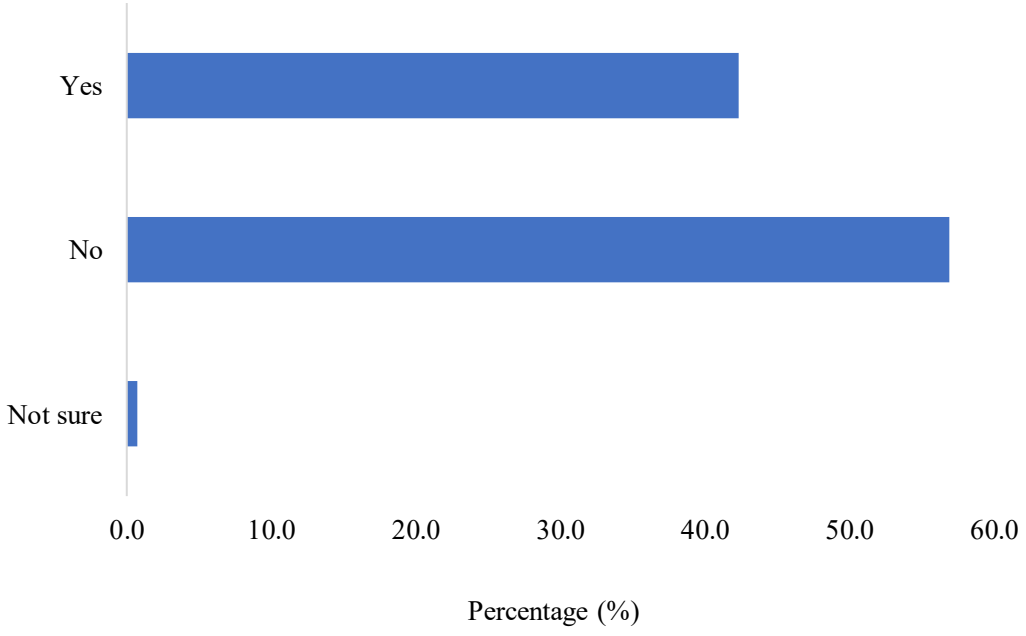

Figure 14: Membership of fish farmers in cooperatives or farmer groups

3.12 Presence of active cooperatives or farmer associations

Most respondents (76.6%) reported no active cooperatives or farmer associations in their area, while 13.9% confirmed their presence and 9.5% were unsure (Fig. 15). This indicates limited access to collective structures, restricting opportunities for knowledge sharing, resource access, market linkages, and technical support. The findings highlight the need to promote and

strengthen cooperatives to enhance productivity, collaboration, and access to markets and extension services.

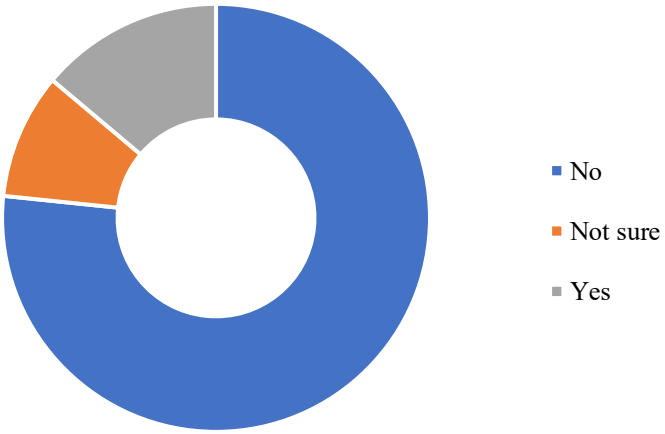

Figure 15: Presence of active cooperatives or farmer associations in the surveyed areas

3.13 Barriers to cooperative participation go beyond availability

Among non-members, the main reasons include a preference for independent operation (14.6%), limited awareness of cooperatives (13.1%), and lack of trust in cooperative management (9.5%) (Table 3).

These results show that the challenge is not only the absence of cooperatives but also issues of governance, trust, and perceived value. Simply increasing the number of cooperatives may therefore be insufficient without improving transparency and demonstrating clear economic benefits

Table 3: Reasons for non-participation in cooperatives among fish farmers

Reason for non-participation in the cooperative	Frequency	Percent (%)
Lack of information about cooperatives	18	13.1
Lack of trust in cooperative management	13	9.5
Prefer to operate independently	20	14.6
No cooperatives nearby	7	5.1
Did not indicate / other	89	65.0

3.14 Strong latent demand for cooperative cold chain solutions

Despite low current participation, there is an overwhelming willingness to engage in collective systems. A large majority (91.2%) of respondents indicate that they would participate in a cooperative cold storage or transport system if available (Fig. 16). This highlights a clear opportunity to leverage existing demand for shared solutions to improve post-harvest handling, reduce losses, and enhance market access.

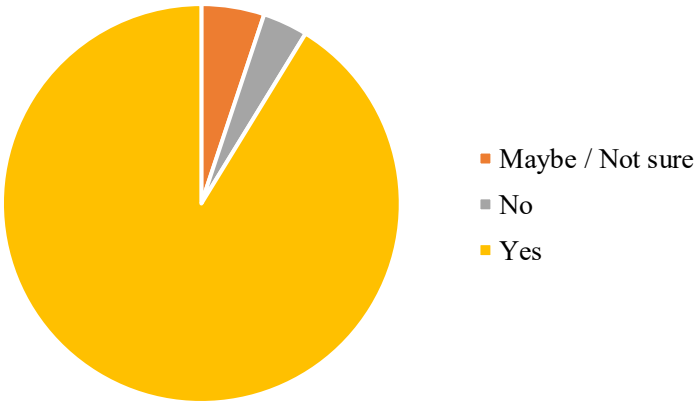

Figure 16: Willingness of fish farmers to participate in a cooperative cold storage or transport system

3.15 Strong demand for public investment and complementary financial and technical support to improve fish storage and transport

Most respondents identified government investment in cold storage facilities as the primary need (76.6%) to improve post-harvest handling and the cold chain (Table 4). Access to financing was also a major constraint (43.1%). Other needs included shared cold storage (12.4%), training in cold chain management and post-harvest handling (11.7%), affordable refrigeration units (10.2%), and improved road and transport infrastructure (7.3%). These findings indicate that improving post-harvest management requires a multi-faceted approach combining public investment, financial support, cooperative solutions, and capacity building to reduce losses and enhance market access and income.

Table 4: Support needs identified by fish farmers to improve post-harvest handling and cold chain management

Support / Intervention Needed	Frequency	Percent (%)
Government investment in cold storage facilities	105	76.6
Access to affordable refrigeration or freezing units	14	10.2
Access to financing to support investments in cold storage	59	43.1
Cooperative or shared cold storage access	17	12.4
Improved road infrastructure and transport networks	10	7.3
Training in cold chain management and post-harvest handling	16	11.7

3.16 Business Models or Approaches for Viable Cold Storage Investment

The results indicate that the most common investment model among respondents is private ownership supported by loans or grants, reported by 52.6% of farmers (Table 5). A significant proportion (38.7%) favours a joint investment or cooperative model, demonstrating interest in collaborative approaches to aquaculture development. Additionally, partnerships with processors or input suppliers (21.9%) and integration with other agricultural products, such as vegetables or meat (19.0%), are also considered viable investment strategies. These results suggest that while individual ownership remains predominant, cooperative and partnership-based models offer important avenues for improving resource sharing, reducing financial risk, and enhancing efficiency. Development programs and policymakers can leverage these preferences by supporting cooperative investment schemes, public-private partnerships, and integrated farming initiatives, which can strengthen post-harvest management, improve market access, and promote sustainable aquaculture growth.

Table 5: Preferred investment models for post-harvest infrastructure among fish farmers

Investment / Partnership Model	Frequency	Percent (%)
Private ownership with loan or grant support	72	52.6
Joint investment or cooperative model with other farmers	53	38.7
Integration with other agricultural products (e.g., vegetables, meat)	26	19.0

Investment / Partnership Model	Frequency	Percent (%)
Partnerships with processors or input suppliers	30	21.9

3.17 Awareness of Government or Private Sector Initiatives Supporting Cold Chain Development for Small-Scale Fish Farmers

Awareness of government or private sector cold chain initiatives among small-scale fish farmers is low, with only 36.5% reporting awareness, while 45.3% are unaware and 18.2% are unsure (Fig. 17). This indicates a substantial information gap that may limit farmers' access to technical support, financing, and infrastructure for improved post-harvest handling and fish quality. Strengthening targeted communication and extension services is therefore essential to improve awareness, increase uptake of available support programmes, and enhance adoption of best practices, ultimately reducing post-harvest losses and improving market access.

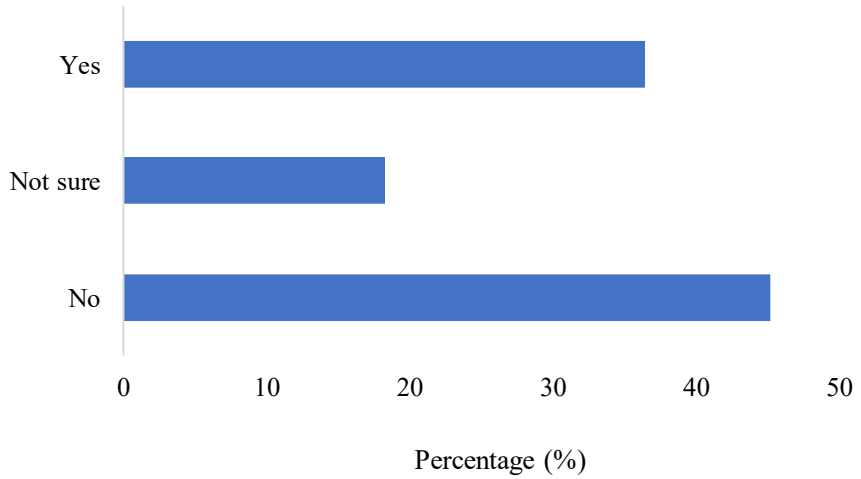

Figure 17: Awareness of government or private sector initiatives supporting cold chain development among small-scale fish farmers

3.18 Additional Comments and Suggestions

Farmers' responses show a clear prioritization of cold chain needs, led by demand for government investment in cold storage infrastructure (48.2%), confirming inadequate storage capacity as the most binding post-harvest constraint (Table 6). Access to financing ranks second (13.9%), highlighting affordability as a key barrier to adopting cold chain technologies. Although training, cooperative storage, and energy solutions were mentioned, they were less prominent, reinforcing that infrastructure and financing remain the primary constraints.

Overall, the findings suggest that without addressing these core gaps, complementary interventions are unlikely to significantly reduce losses, improve fish quality, or expand market access.

Table 6: Key support and interventions needed by fish farmers to improve cold storage and post-harvest handling.

Suggestion	Frequency	Percent (%)
Government investment in cold storage facilities	66	48.2
Government support / grants / loans	19	13.9
Access to affordable refrigeration or freezing units	11	8.0
Training in cold chain management and post-harvest handling	12	8.8
Improved road infrastructure and transport networks	4	2.9
Cooperative / shared cold storage	7	5.1
Solar-powered refrigeration / cold storage	5	3.6
Stable / backup electricity/power supply	3	2.2
Private ownership with loan or grant support	2	1.5
Other/miscellaneous suggestions	8	5.8
Total	137	100.0

4 STAKEHOLDERS

4.1 Institutional landscape: government-led with emerging multi-stakeholder engagement

Institutional support to fish farmers is primarily driven by government actors, cited by 40% of respondents, followed by local authorities (30%) and private sector actors (30%) (Fig. 18). This indicates that while the public sector remains the central driver of support, there is increasing involvement of other stakeholders. Additionally, the sector is dominated by small-scale enterprises (79.1%), with few medium-scale businesses (20.9%), reflecting limited operational capacity and influencing access to finance, technology adoption, and participation in value chain activities (see Annex section 3). Overall, the institutional landscape reflects a

government-led system with emerging but still limited multi-stakeholder participation, suggesting opportunities to strengthen coordination and expand private sector engagement.

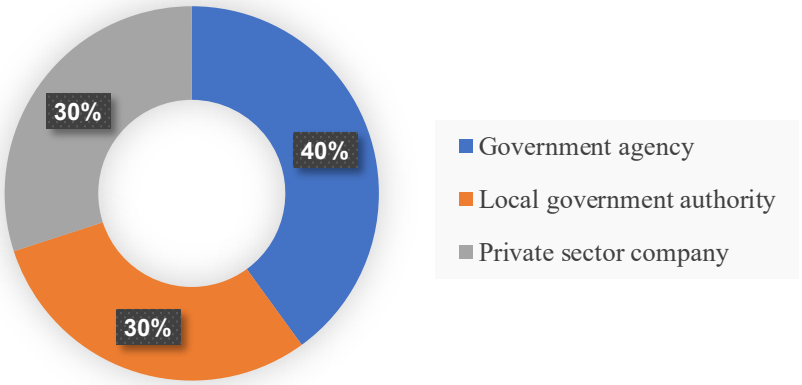

Figure 18: Types of Institutions Supporting Fish Farmers

4.2 Limited and fragmented institutional support for cold chain development

Institutional support for cold chain infrastructure remains limited. A large majority (80%) of institutions report no direct financial support, and half provide no cold chain-related support at all (Fig. 18).

Among institutions that do provide support, interventions are distributed across:

- financial assistance (40%)
- policy and regulatory engagement (30%)
- training and capacity building (30%)

Table … shows that institutional engagement is uneven and fragmented, with no integrated approach linking financing, policy, and capacity development. These results show that while some institutional support exists, it is fragmented and not systematically coordinated across financing, regulation, and capacity development functions. This limits the scale and effectiveness of cold chain investment in the sector.

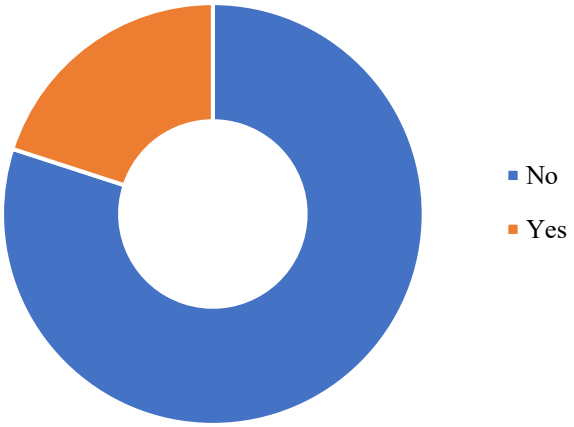

Figure 19: Institutional Financial Support for Cold Chain Infrastructure in Aquaculture

4.3 Institutional support for cold chain infrastructure: fragmented engagement with uneven and limited coverage

Half of the institutions (50%) reported no specific support for cold chain infrastructure. Among those providing support, 40% offer financial assistance, while 30% are involved in policy development and regulatory enforcement, and another 30% provide training and capacity building on cold chain management (Table 7). Overall, institutional support is uneven and fragmented, with financial assistance being the most common intervention. However, limited engagement in policy, regulation, and capacity building, combined with the absence of support from half of the institutions, indicates weak coordination and low prioritization of cold chain systems. These findings highlight the need for a more coordinated approach linking financing, policy alignment, and capacity development, alongside strengthened institutional collaboration to improve coherence and effectiveness across the aquaculture value chain.

Table 7: Forms of Institutional Support for Cold Chain Infrastructure

Support / Intervention Provided	Frequency	Percent (%)
None indicated	5	50.0
Financial support for cold chain infrastructure	4	40.0
Policy development and regulation enforcement	3	30.0
Training and capacity building on cold chain management	3	30.0

Support / Intervention Provided	Frequency	Percent (%)
Total	10	100.0

4.4 Institutional Collaboration with Farmers and Modes of Engagement

Most institutions (70%) collaborate with small-scale fish farmers on improving storage and transport systems, while 30% do not engage in such collaboration (Fig. 20). Among those that collaborate, engagement is mainly through technical training and workshops (60%) and financial support for cold chain facilities (40%).

Across all collaborating institutions, support is further expressed through training and capacity building (60%), technical advisory services (50%), policy coordination (40%), and market linkages (40%), while fewer institutions provide financial support (30%) or equipment and logistical assistance (20%) (Table 8).

Overall, institutional engagement is relatively strong on the technical and advisory side, but weaker in terms of direct infrastructure provision and financial enablement required for cold chain implementation.

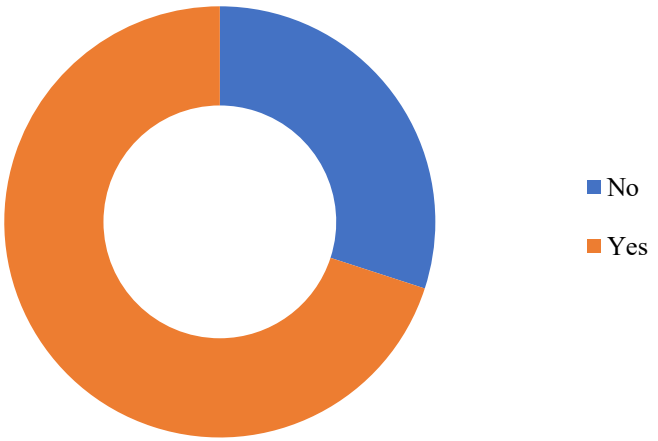

Figure 20: Institutional Collaboration with Small-Scale Fish Farmers on Cold Chain Improvement

4.5 Institutional engagement with fish farmers: training dominates, with limited but important financial support

Among institutions working with small-scale fish farmers, 60% provide technical training and workshops, while 40% offer funding for cold chain facilities (Fig. 21), with some delivering both. All 10 institutions reported at least one form of support, indicating active engagement in improving fish storage and transport. However, support is largely skewed toward capacity building, reflecting a strong emphasis on knowledge and skills in post-harvest handling and cold chain management. The lower provision of financial support highlights ongoing constraints in translating knowledge into infrastructure, especially for resource-limited farmers.

Institutions that combine training with financial support demonstrate a more integrated approach, linking capacity development with investment, and are more likely to achieve sustained improvements. Overall, the findings suggest the need for coordinated, integrated support models that combine training with financing mechanisms (e.g., grants, credit, or cost-sharing) to enhance adoption of cold chain systems, reduce post-harvest losses, and improve farmer incomes.

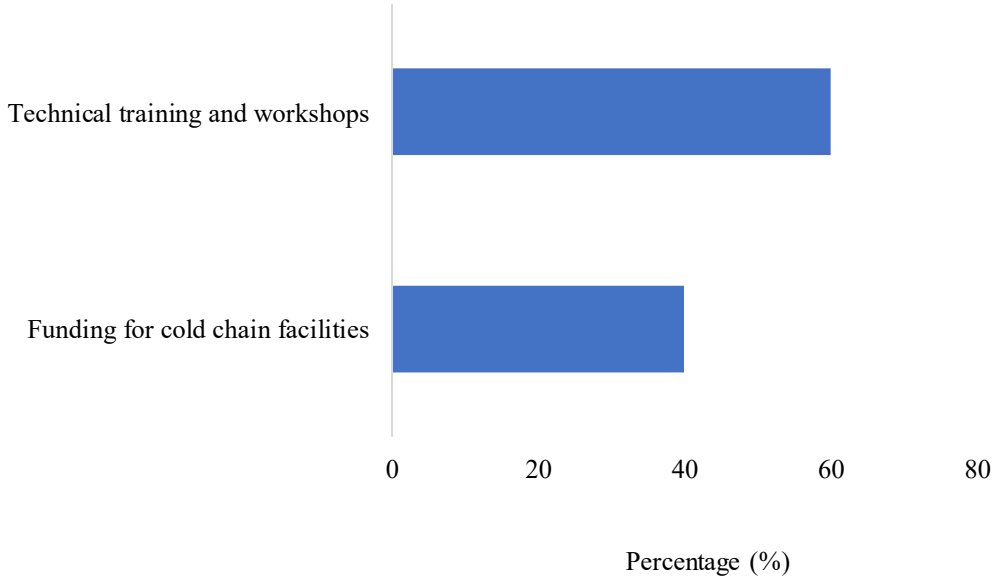

Figure 212: Modes of Institutional Engagement with Small-Scale Fish Farmers

Barriers to cold chain development: dominated by cost and rural infrastructure constraints

Across institutions, the most critical barriers to cold chain development are:

- high cost of refrigeration facilities (90% major constraint)
- lack of investment in rural areas (100% major or very major)
- inadequate policy support (mixed but significant concern)

Results presented in Table 8 highlight that financial and infrastructure constraints outweigh technical skill limitations.

At the farmer level, similar barriers are observed, particularly:

- lack of cold storage and ice facilities
- poor transport infrastructure
- high energy costs

Table 8 further confirms that infrastructure and cost-related barriers are the most binding constraints affecting adoption.

Table 8: Perceived Barriers to Cold Chain Development and Fish Storage

Barrier / Challenge	Not a Barrier (%)	Minor Barrier (%)	Moderate Barrier (%)	Major Barrier (%)	Very Major Barrier (%)
High cost of refrigeration facilities	0	0	10	90	0
Limited technical skills and knowledge	0	50	50	0	0
Lack of investment in rural areas	0	0	0	70	30

Barrier / Challenge	Not a Barrier (%)	Minor Barrier (%)	Moderate Barrier (%)	Major Barrier (%)	Very Major Barrier (%)
Inadequate policies or government support	20	0	20	50	10

4.6 Institutional training and research support: limited coverage but strong academic role

Only 40% of institutions provide training on cold chain and post-harvest handling, while 60% offer no training. Among those providing training, coverage varies from basic fish handling to more comprehensive programmes, including:

- refrigeration technologies
- food safety standards
- transport logistics

As highlighted in Table 9, training remains limited in both coverage and depth.

In contrast, universities and research institutions demonstrate strong engagement:

- 100% involved in research on cost-effective cold storage
- 90% engaged in curriculum development
- 50% provide field demonstrations
- 40% collaborate with the private sector

Table 9: Types of Training Provided by Institutions to Fish Farmers

Training Content / Focus Area	**Frequency**	**Percent (%)**
No training provided	6	60.0
Proper fish handling and storage practices	1	10.0
Proper fish handling and storage practices, HACCP and food safety standards	1	10.0

Training Content / Focus Area	Frequency	Percent (%)
Proper fish handling and storage practices, Use of refrigeration and freezing technologies, HACCP and food safety standards, Transport logistics for fresh and frozen fish	2	20.0
Total	10	100.0

These findings highlight universities and research institutions as key knowledge and innovation hubs, particularly in addressing affordability constraints and embedding cold chain concepts into training systems (Table 10). However, relatively weaker private sector collaboration limits opportunities for scaling and commercialisation. Strengthening partnerships between academia, industry, and development actors is therefore essential to accelerate adoption and expand cold chain solutions.

Table 10: Roles of Universities and Research Institutions in Cold Chain Development

Support / Intervention Type	Frequency	Percent (%)
Curriculum development on cold chain and post-harvest management	9	90.0
Field demonstrations and practical training	5	50.0
Research on cost-effective cold storage solutions	10	100.0
Partnerships with the private sector to improve infrastructure	4	40.0

4.7 Awareness of Standards Among Small-Scale Fish Farmers

The results show that awareness of existing standards among small-scale fish farmers is moderate, with 50% reporting awareness (Fig. 22). This indicates that half of the farmers are aware, while the remaining 50% are not, pointing to uneven knowledge levels across the sector. Such gaps may contribute to weak adoption of best practices in fish handling, storage, and transport, increasing the risk of post-harvest losses and limiting market compliance and income opportunities.

The findings highlight the need for targeted awareness and capacity-building interventions to strengthen understanding of cold chain and food safety standards. Integrating training,

demonstrations, and farmer field-based approaches can improve compliance, reduce losses, and enhance market access and competitiveness.

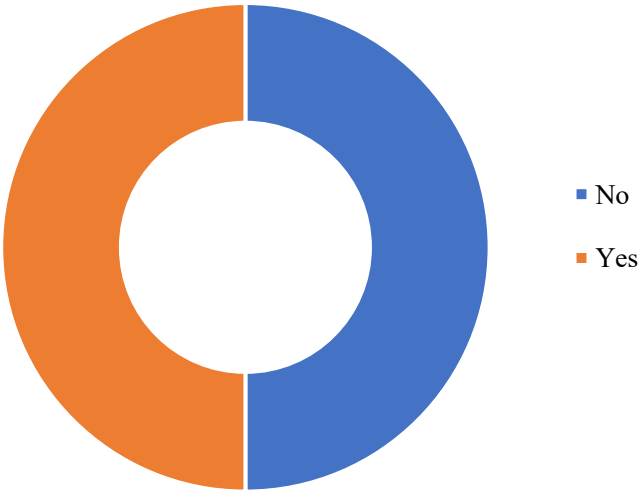

Figure 223: Awareness of Cold Chain and Post-Harvest Standards Among Small-Scale Fish Farmers

4.7.1 Measures to improve adoption

Stakeholders emphasize that improving adoption of cold chain practices requires a combination of interventions, including:

- training and extension support
- financial incentives and subsidies
- access to shared or mobile cold storage systems
- market incentives such as certification

Table 11 further shows that no single intervention is sufficient, and integrated approaches are required. Overall, these findings suggest that awareness strategies should be multi-pronged, integrating extension services, community campaigns, education systems, and simple, locally relevant materials. Strengthening structured awareness efforts can improve adoption of best practices, enhance compliance with standards, reduce post-harvest losses, and ultimately support better market access and incomes for small-scale fish farmers.

Table 11: Frequency of Recommended Measures to Enhance Awareness Among Fish Farmers

Response option	Frequency	Percent (%)
Did not specify any method	5	50.0
Increased extension services and farmer training; awareness campaigns via media or community; distribution of guides/posters in local languages.	1	10.0
Increased extension services and farmer training; awareness campaigns via media or community; inclusion of hygiene and storage modules in education; distribution of guides/posters in local languages.	4	40.0
Total	**10**	**100.0**

4.8 Implementation of Hygiene Practices and Cold Chain Storage by Small-Scale Fish Farmers

The results indicate generally low and inconsistent adoption of hygiene practices and cold chain storage among small-scale fish farmers. One-fifth (20.0%) report that these practices are not implemented at all, 40.0% indicate they are rarely applied, and the remaining 40.0% report that they are only implemented sometimes (Fig. 23). Overall, no respondents report regular or consistent use of proper hygiene and cold chain measures.

These findings suggest a clear gap between awareness and practice, where occasional application does not translate into sustained behaviour change. This is likely driven by constraints such as limited technical skills, inadequate infrastructure, financial limitations, and weak institutional support. As a result, post-harvest losses persist, fish quality is compromised, and compliance with food safety standards remains low.

The results highlight the need for interventions that promote consistent adoption of good practices through hands-on training, regular extension follow-up, demonstration sites, and improved access to affordable storage technologies. Strengthening monitoring systems and introducing incentives for compliance can further support sustained behavioural change. Addressing both knowledge and practical constraints together is essential for reducing losses, improving fish quality, and enhancing market outcomes for small-scale farmers.

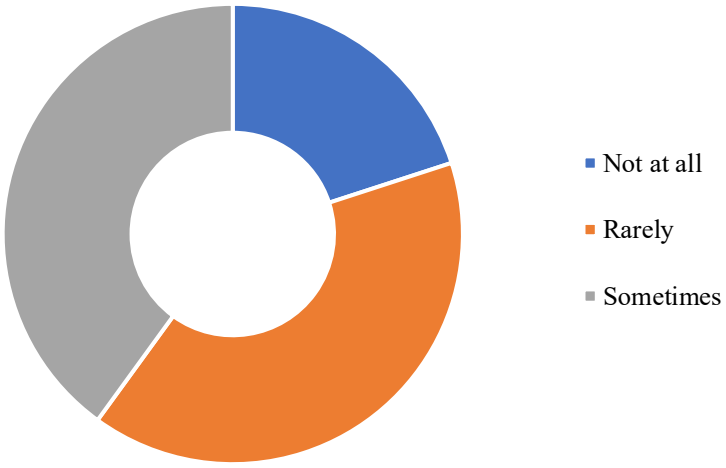

Figure 23: Adoption Levels of Hygiene and Cold Chain Practices Among Small-Scale Fish Farmers

4.9 Barriers to Cold Chain Development Across Stakeholders

Across institutions, the most prominent barrier is the high cost of refrigeration facilities, cited by 90% of respondents as a major constraint. This is followed by lack of investment in rural areas, reported as a major or very major barrier by all respondents (70% major, 30% very major), and inadequate policy support, which is considered a major to moderate constraint by most respondents (Table 12).

At the farmer level, similar structural constraints dominate. Limited access to ice and freezing technologies is reported as a major barrier by 80% of respondents, poor transport infrastructure is rated as major or moderate by 80%, and high energy costs are identified as a major or very major barrier by 60% (Table 4.8). Technical skills are generally seen as a secondary constraint compared to infrastructure and cost-related issues. Overall, the evidence points to financial, infrastructural, and energy constraints as the most binding limitations across the cold chain system.

Table 12: Barriers to Adoption of Hygiene and Cold Chain Practices Among Small-Scale Fish Farmers

Barrier	Frequency	Percent (%)
Lack of infrastructure (e.g., ice, cold storage units)	9	90.0
Limited knowledge or training	6	60.0

Barrier	Frequency	Percent (%)
Lack of enforcement or regulation	5	50.0
The perception that it is not necessary for local markets	5	50.0
High cost of compliance	4	40.0

4.10 Measures to Improve Compliance

Stakeholders consistently emphasize a combination of interventions to improve compliance. These include regular training and monitoring by extension officers, subsidies or incentives for cold chain equipment, access to mobile or cooperative storage systems, and market-based incentives such as certification schemes (Table 13). The results indicate that compliance is not viewed as dependent on a single intervention, but rather on a combination of technical support, financial affordability, infrastructure access, and market incentives.

Table 13: Measures Recommended to Improve Compliance with Cold Chain and Post-Harvest Practices

Measures to Promote Compliance	Frequency	Percent (%)
Regular training and monitoring by extension officers; Support from government or development partners; Market demand or certification-linked benefits	3	30.0
Subsidies or incentives for cold chain equipment; Mobile cold storage or cooperative-owned facilities; Regular training and monitoring by extension officers; Support from government or development partners	2	20.0
Subsidies or incentives for cold chain equipment; Regular training and monitoring by extension officers; Support from government or development partners	2	20.0
Mobile cold storage or cooperative-owned facilities; Regular training and monitoring by extension officers; Support from government or development partners	1	10.0
Subsidies or incentives for cold chain equipment; Mobile cold storage or cooperative-owned facilities	1	10.0

Measures to Promote Compliance	Frequency	Percent (%)
Subsidies or incentives for cold chain equipment; Mobile cold storage or cooperative-owned facilities; Regular training and monitoring by extension officers; Support from government or development partners; Market demand or certification-linked benefits	1	10.0
Total	**10**	**100.0**

4.11 Infrastructure Constraints and Cold Storage Access

Lack of affordable cold storage facilities is identified as a major constraint by 80% of respondents, with most classifying it as a major or very major barrier (Fig. 24). This is reinforced by broader constraints including limited access to ice and freezing technologies (80% major barrier), inadequate transport infrastructure (40% major and 40% moderate barrier), and high energy costs (40% major, 20% very major barrier) (Table 14). These challenges collectively reduce farmers' ability to maintain fish quality and extend shelf life, thereby directly affecting market access and income stability.

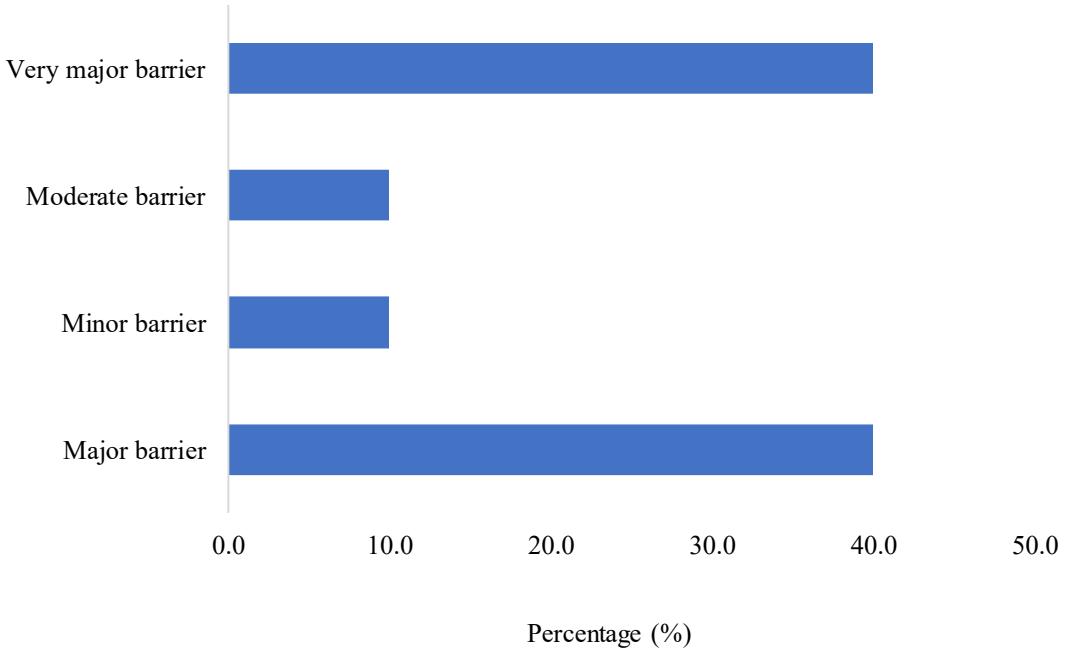

Figure 244: Challenge Level of Lack of Affordable Cold Storage Facilities Among Respondents

4.12 Extent to Which These Barriers Affect Farmers or Producers

Table 14: Challenges in Cold Chain and Transportation for Small-Scale Fish Farmers

Challenge	Minor Barrier (%)	Moderate Barrier (%)	Major Barrier (%)	Very Major Barrier (%)	Total (%)
Limited access to ice and freezing technologies	10	10	80	0	100
Poor road and transport infrastructure	20	40	40	0	100
High cost of energy for refrigeration	20	20	40	20	100

4.13 Best strategies to improve cold chain infrastructure

There is a strong consensus on priority strategies for cold chain improvement. All respondents (100%) emphasize government investment and farmer training, while 70% highlight public-private partnerships and 30% suggest research into alternative energy sources such as solar technologies (Table 15). This reflects agreement on a multi-dimensional approach combining infrastructure investment, capacity building, and technological innovation.

Table 15: Stakeholder-Recommended Interventions for Strengthening Cold Chain Systems

Support / Intervention Needed	Frequency	Percent (%)
Government investment in cold storage and transport systems	10	100.0
Increased farmer training and awareness programs	10	100.0
Research on alternative energy sources (e.g., solar)	3	30.0
Public-private partnerships for cold chain financing	7	70.0

4.14 Policy Awareness, Institutional Coordination, and Collaboration

Awareness of government and donor-funded cold chain initiatives is moderate, with 70% of institutions reporting awareness and 30% indicating limited awareness or uncertainty (Fig. 25). This suggests that information dissemination is not fully effective across all stakeholders.

Despite this, institutional willingness to collaborate is high (80%) (Fig. 26), with collaboration mainly focused on training and technical support (60% and 50%, respectively), and less on financial, equipment, or logistical support (20–30%). This indicates strong potential for coordination, although gaps in awareness and resource-based collaboration still exist.

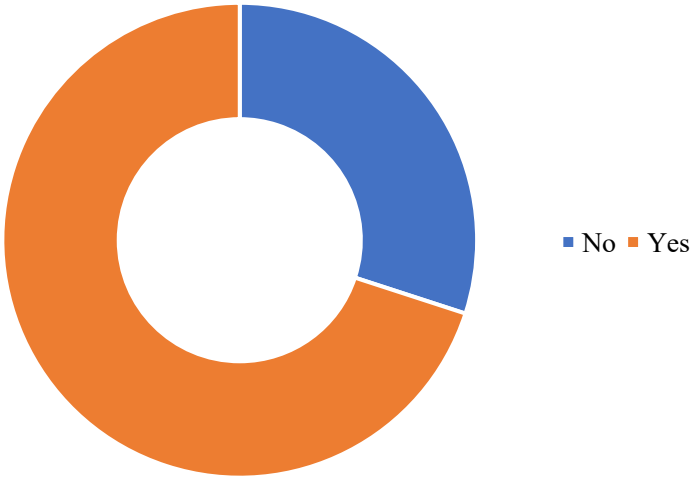

Figure 25: Institutional Awareness of Cold Chain Support Programs

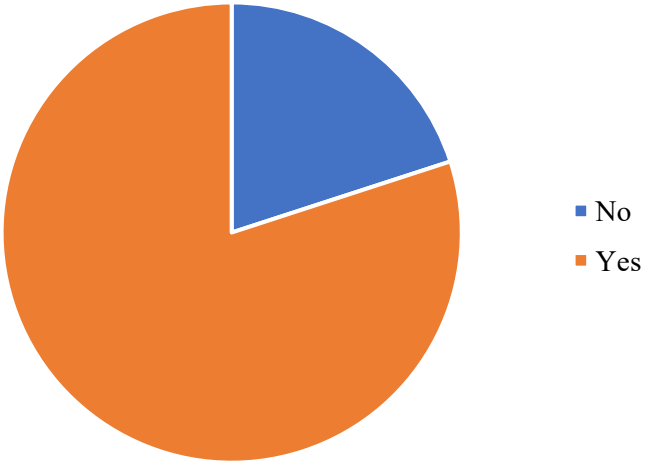

Figure 26: Institutional Interest in Collaborating with Other Stakeholders to Support Cold Chain Development

4.14.1 Ways Your Institution Would Collaborate

Out of the 10 institutions collaborating with small-scale fish farmers, most provide training and capacity building (60%), while half offer technical expertise and advisory services (50%). A smaller proportion coordinates with the government on policy and market linkages (40%) and supports research, data collection, and monitoring (40%). Fewer institutions provide financial support (30%) or equipment and logistical assistance (20%), and 20% did not specify a form of collaboration (Table 16).

Overall, institutional support is concentrated on capacity building and technical guidance, with limited provision of financial and infrastructural support needed for practical implementation. This imbalance suggests the need for development projects to complement existing efforts by strengthening financing mechanisms, providing equipment and logistical support, and improving coordination across institutions to integrate training, infrastructure, market access, and research for more effective cold chain adoption and improved farmer outcomes.

Table 16: Types of Institutional Collaboration and Support for Cold Chain and Post-Harvest Practices

Collaboration type	Frequency	Percent (%)
Facilitate training and capacity building	6	60
Provide technical expertise and advisory services	5	50
Coordinate with the government to influence policy	4	40
Assist with market linkages and product distribution	4	40
Support research, data collection, and monitoring	4	40
Offer financial support or investment	3	30
Provide equipment or logistical support	2	20
Not specified	2	20

4.15 Additional Comments and Recommendations

Additional recommendations include the development of mobile cold storage systems managed by government or private actors (10%), strengthening farmers' financial literacy (10%), increasing targeted training on cold chain and post-harvest handling (10%), and promoting bulk marketing to reduce transport costs (30%) (Table 17). Collectively, these suggestions highlight the importance of shared infrastructure, improved business skills, and collective action approaches to strengthen cold chain efficiency and reduce operational costs for small-scale fish farmers.

Table 17: Additional Comments and Recommendations from Institutions

Recommendations	Frequency	Percent (%)
No additional comments	4	40.0
Government or private sector to procure mobile cold chain for small-scale farmers	1	10.0
Improve operations in sales management and financial understanding	1	10.0
Train more farmers in cold chain infrastructure	1	10.0
Encourage farmers to bulk products to reduce transport costs	3	30.0

5 OFFTAKERS

5.1 Type of Business

The offtaker segment is dominated by butcheries and fishmongers (31.3% each), followed by fish processors (23.9%) (Fig. 27). In contrast, cold storage operators and fish traders each account for only 6.0%, while group companies represent a very small proportion (1.5%). This distribution indicates that the value chain is primarily driven by retail and processing activities, with limited participation in storage and logistics. As a result, most businesses operate with minimal preservation capacity, contributing to product quality deterioration, post-harvest losses, and unstable incomes.

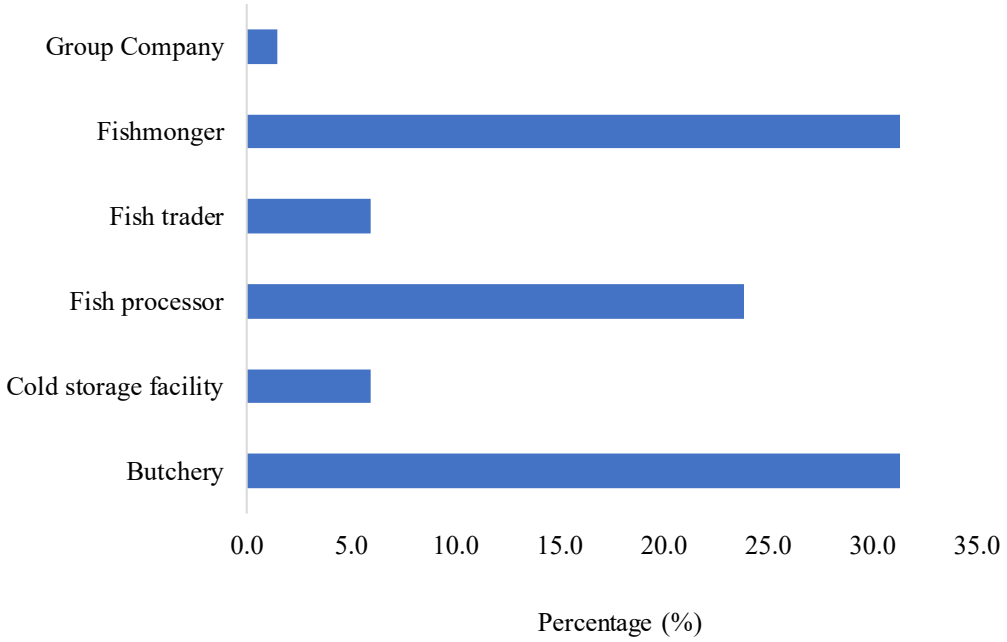

Figure 27: Business Types Among Meat and Fish Value Chain Stakeholders

5.2 Ownership and scale of operations

Most businesses are privately owned (82.1%), with limited representation of cooperatives and public-private partnerships (7.5% each) (Fig. 28). This reflects a largely independent operational structure with minimal collective ownership.

In terms of scale, the sector is dominated by small-scale enterprises (79.1%), with only 20.9% classified as medium-scale. This structure indicates limited capital capacity, restricted access to financing, and constrained ability to invest in cold chain infrastructure. Together, ownership and scale characteristics suggest that investment in storage, processing, and logistics remains fragmented across individual operators.

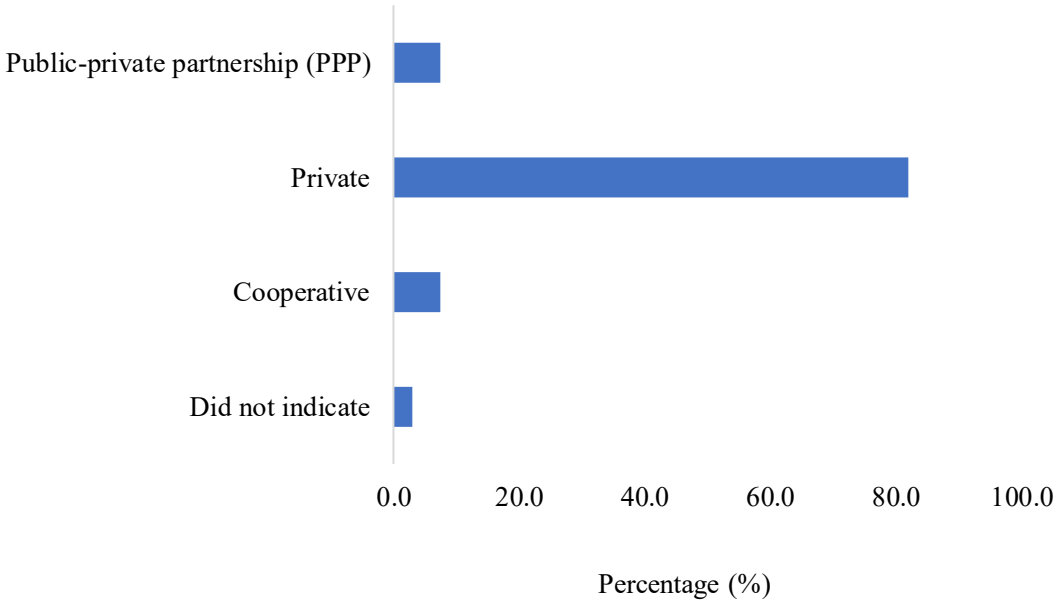

Figure 28: Ownership Types of Meat and Fish Value Chain Business Outlets

5.3 Geographic distribution and business maturity

Business operations are concentrated in Lusaka (53.7%), followed by smaller clusters in Kaoma (14.9%), Gwembe and Kabwe (11.9% each), with limited presence in Kasama and Kitwe (Fig. 29). This spatial pattern reflects the concentration of market demand, infrastructure, and customer access in urban centres, particularly Lusaka.

In terms of experience, nearly half of businesses (49.3%) have operated for 1–5 years, indicating a relatively young and evolving sector. Smaller proportions have longer operational histories, reflecting mixed experience levels across stakeholders.

This combination of geographic concentration and relatively young enterprises continues to influence how businesses access supply chains, adopt technologies, and invest in infrastructure.

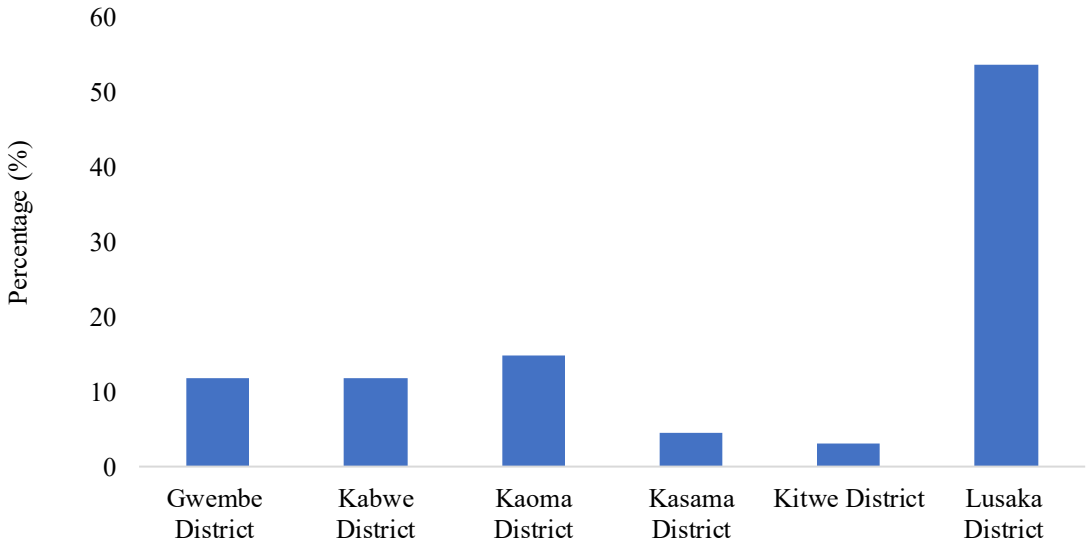

Figure 29: Geographic Distribution of Meat and Fish Value Chain Businesses by District

5.4 Years of operation

Among the surveyed businesses, nearly half (49.3%) operate for 1-5 years, while 26.9% have been in operation for 6-10 years. Smaller proportions operate for 11-15 years (10.4%) and 16 years or more (13.4%) (Fig. 30). This distribution shows that the sector is largely composed of relatively new businesses, with a mix of experience levels across stakeholders. The prevalence of younger enterprises continues to influence how businesses manage operations, adopt improved practices, access financing, and invest in infrastructure, shaping the growth and stability of the meat and fish value chain.

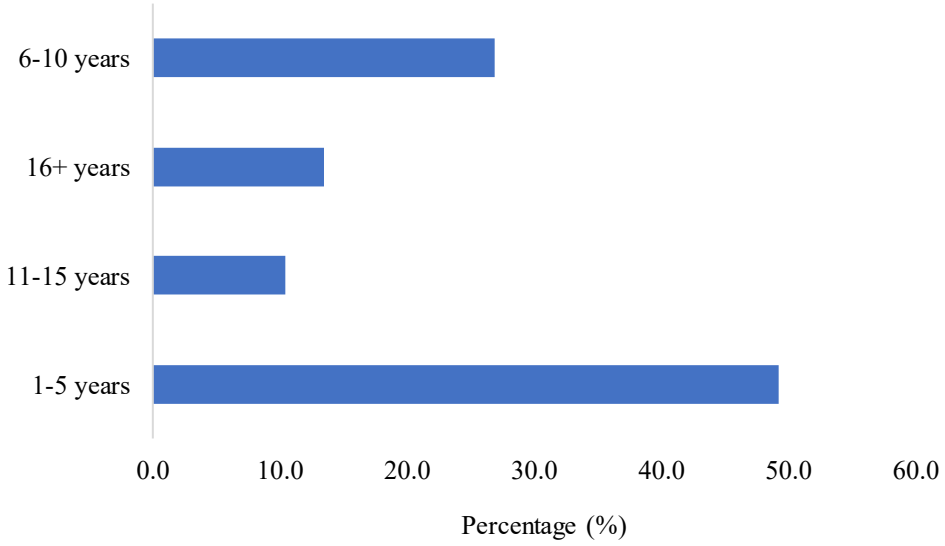

Figure 30: Years of Operation of Meat and Fish Value Chain Businesses.

5.5 Current Fish Purchases from Small-Scale Aquaculture Farms

Among the surveyed businesses, the majority (64.2%) purchase fish from small-scale aquaculture farms, while 35.8% do not (Fig. 31). This shows a relatively strong engagement between small-scale aquaculture producers and market actors, highlighting that many stakeholders are actively linked to local fish production. The ongoing interaction with small-scale farms continues to influence how businesses source their products, maintain supply consistency, and respond to market demand, shaping the development and integration of aquaculture within the broader meat and fish value chain.

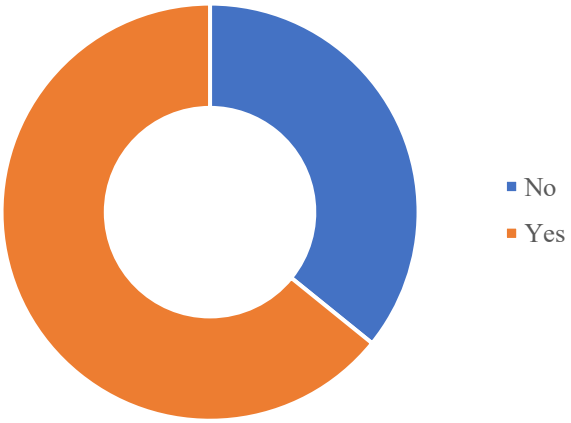

Figure 315: *Engagement of Businesses with Small-Scale Aquaculture Producers*

5.6 Uneven access to cold chain infrastructure and reliance on short-term storage

Among the surveyed businesses, ownership or access to cold chain infrastructure is evenly split, with 46.3% having access, 46.3% lacking access, and 7.5% reporting partial access (Fig. 32). This shows that while nearly half of the businesses are equipped to handle cold storage, a similar proportion faces limitations in maintaining product quality. The ongoing disparity in access to cold chain facilities continues to shape how stakeholders store, transport, and sell perishable fish and meat products, influencing post-harvest losses, product safety, and market reliability across the sector.

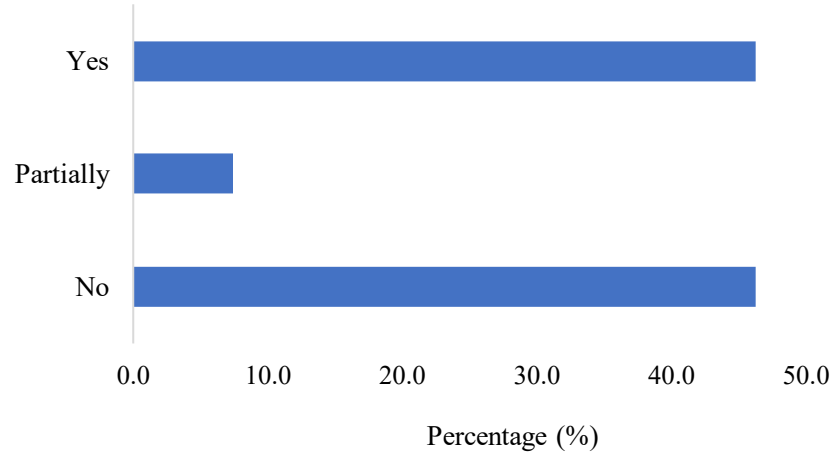

Figure 32: Ownership or Access to Cold Chain Infrastructure Among Businesses

5.7 Types of Cold Chain Facilities Used

Among the surveyed businesses, the most commonly available cold chain facility is ice boxes, reported by 74.6 % of respondents. Freezer units are available to 31.3 %, walk-in cold rooms to 23.9 %, refrigerated display units to 16.4 %, and insulated vehicles to 7.5 % (Table 18). Some businesses have multiple types of cold chain equipment, while 9.0 % have no cold chain facility at all. These results show that ice boxes form the backbone of cold chain infrastructure, while advanced options such as walk-in cold rooms and insulated vehicles remain limited, affecting how stakeholders maintain product quality, extend shelf life, and handle transport and storage of perishable fish and meat products.

Table 18: Types of Cold Chain Facilities Available Among Businesses.

Cold Chain Facility	Frequency	Percent (%)
Ice boxes	50	74.6
Freezer units	21	31.3
Walk-in cold rooms	16	23.9
Refrigerated display units	11	16.4
Insulated vehicles	5	7.5
None	6	9.0

5.8 Average Duration of Fish Storage for Resale or Processing

Among the respondents, most businesses store fish for a short period before resale or processing, with 34.3% storing for 1–2 days, 25.4% for less than 1 day, and another 25.4% for 3–5 days. Only 14.9% store fish for more than 5 days (Fig.33). This shows that stakeholders prioritize quick turnover, likely influenced by limited cold chain facilities and the need to maintain product freshness. The ongoing short storage period continues to shape how businesses plan operations, manage supply, and ensure quality for customers across the meat and fish value chain.

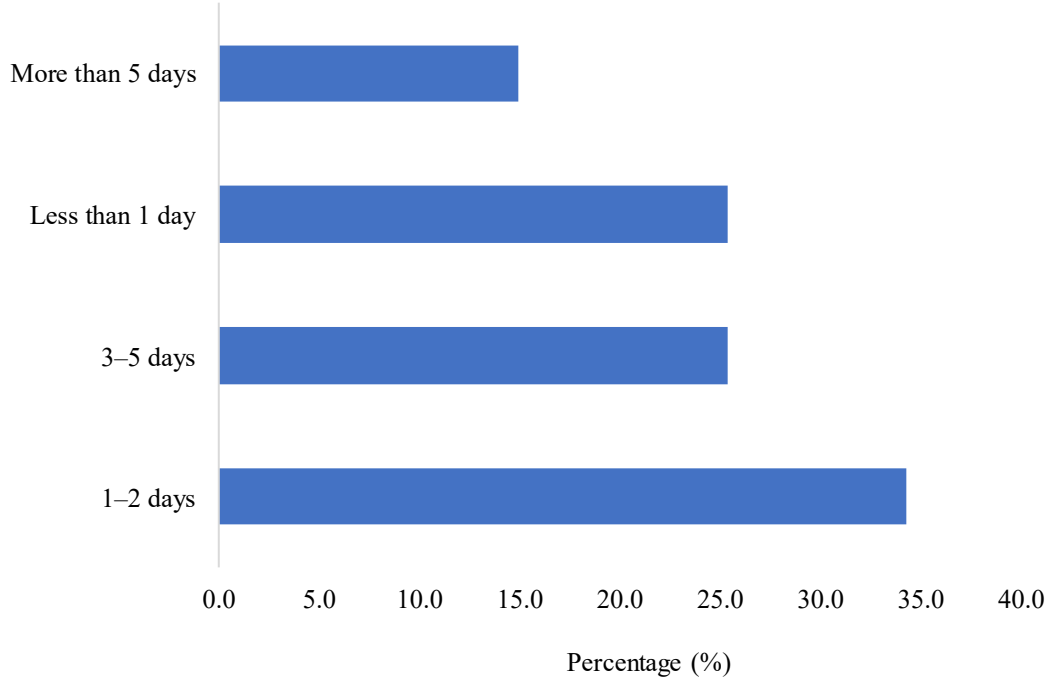

Figure 33: Average Duration of Fish Storage Before Resale or Processing.

5.9 Key Challenges Affecting Cold Chain Operations Among Fish Businesses

Cold chain operations are primarily constrained by high equipment costs (86.6% major or very major) and unreliable power supply (89.6%), followed by limited ice availability (82.1%) (Table 19). Other challenges include high operating costs for fuel and maintenance (about 90% major or very major), while around 42–43% report issues of inconsistent fish quality and transport spoilage. Limited knowledge of cold chain management affects 31.3% of businesses. Overall, financial, energy, and logistical constraints dominate, shaping storage, transport, and product quality management.

Table 19: Key Challenges Affecting Cold Chain Operations Among Fish Businesses.

Challenge	None (%)	Minor (%)	Moderate (%)	Major (%)	Very major (%)
High cost of cold storage equipment	1.5	6.0	6.0	62.7	23.9
Unreliable power supply	3.0	4.5	3.0	64.2	25.4
Limited supply of ice	3.0	4.5	10.4	65.7	16.4
Inconsistent fish quality from suppliers	3.0	9.0	13.4	31.3	10.4
Spoilage during transport	3.0	7.5	14.9	31.3	11.9
Limited knowledge on cold chain management	3.0	9.0	13.4	20.9	10.4
High operating costs for fuel and maintenance	1.5	6.0	3.0	50.7	19.4

5.10 Frequency of Spoilage or Quality Deterioration in Fish Source

Among the surveyed fish businesses, spoilage or quality deterioration in fish sources occurs with varying frequency. The majority (62.7%) report experiencing it sometimes, while smaller proportions report it rarely (11.9%) or often (9.0%). Notably, 16.4% indicate it happens very often, showing that a significant portion of stakeholders face frequent quality losses (Fig.34). These challenges continue to shape how businesses manage storage, transport, and handling practices, with most respondents based in Lusaka having some access to alternative energy sources that support cold storage, which may reduce spoilage. The ongoing presence of spoilage emphasizes the need for strengthened cold chain infrastructure, improved handling, and consistent energy access across the sector.

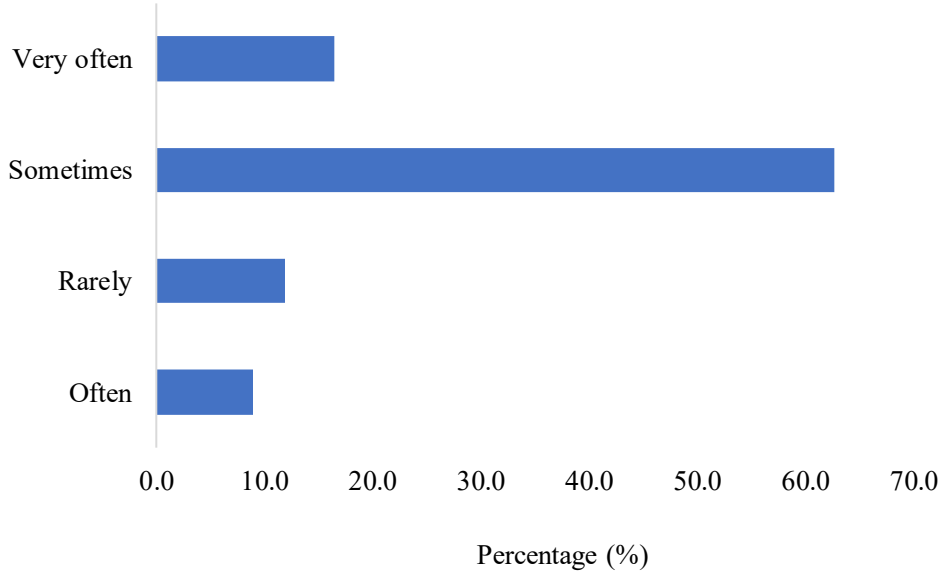

Figure 34: Frequency of Fish Spoilage or Quality Deterioration Among Businesses

5.11 Confidence in Identifying Signs of Fish Spoilage

Among the surveyed businesses, the majority demonstrate strong confidence in identifying signs of fish spoilage. More than half (55.2%) strongly agree that they can easily recognize spoilage, while 37.3% agree, and only a small proportion remain neutral (3.0%) or disagree (4.5%) (Fig. 35). This shows that most stakeholders effectively detect spoilage, which continues to influence how they manage quality, make timely sales or processing decisions, and reduce losses. The widespread confidence in spoilage recognition supports ongoing quality management practices across the fish value chain.

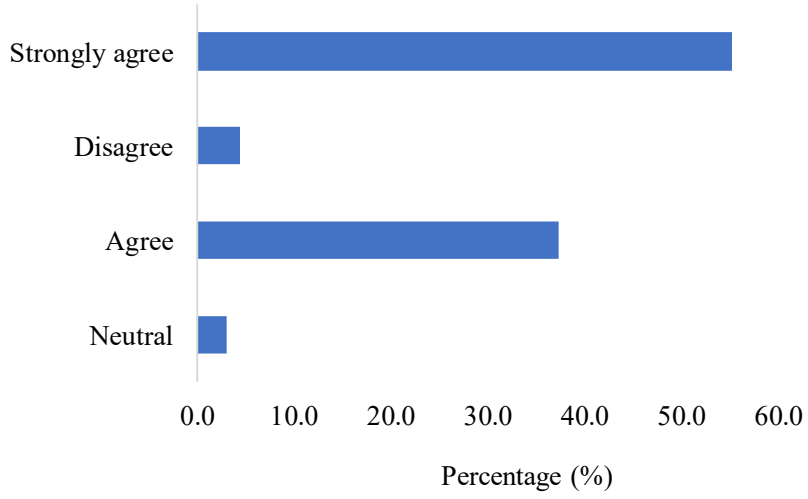

Figure 35: Confidence of Businesses in Identifying Fish Spoilage

5.12 Perception of Cold Storage in Reducing Fish Spoilage

Respondents express mixed opinions on the role of cold storage in reducing fish spoilage. About 37.3% strongly agree and 19.4% agree that cold storage significantly prevents spoilage, while 38.8% remain neutral and 4.5% disagree (Fig. 36). This shows that while a majority recognize the value of cold storage in maintaining fish quality, a substantial portion of stakeholders continues to be uncertain, influencing how businesses adopt, invest in, and manage cold chain infrastructure. The ongoing variation in perception highlights the importance of raising awareness and providing training on effective cold chain practices across the sector.

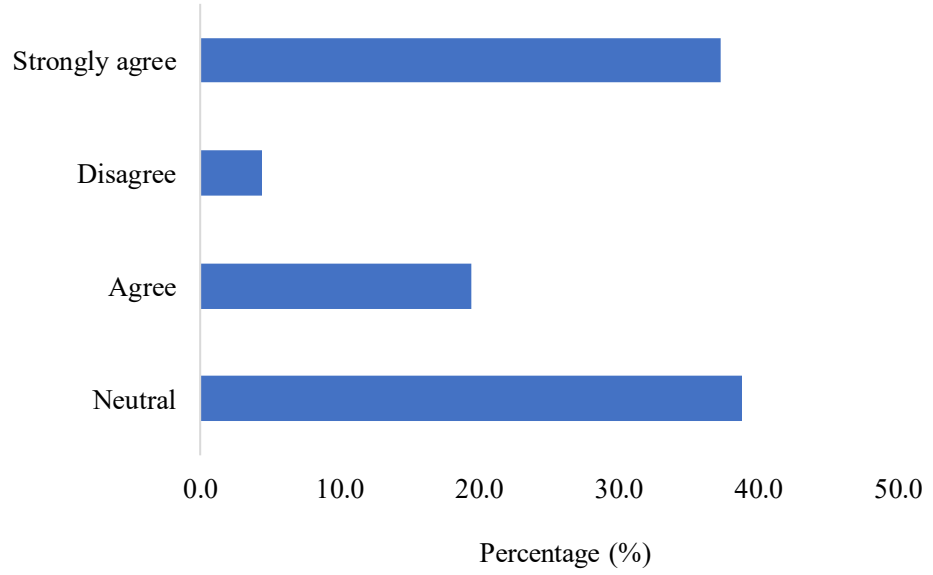

Figure 36: Perceptions on the Role of Cold Storage in Reducing Fish Spoilage

5.13 Effects of poor storage on taste and safety of fish

Respondents indicate a strong understanding that poor storage affects the taste and safety of fish. A majority (61.2%) strongly agree and 26.9% agree that inadequate storage compromises both taste and safety, while 11.9% of respondents do not indicate their opinion (Fig.37). This shows that stakeholders are highly aware of the direct consequences of poor storage practices, including impacts on both product quality and consumer safety. The widespread recognition of these effects continues to influence how businesses manage storage practices, maintain cold chain infrastructure, and make decisions regarding handling, transportation, and resale of fish,

highlighting the ongoing importance of investing in proper cold chain facilities and training across the sector.

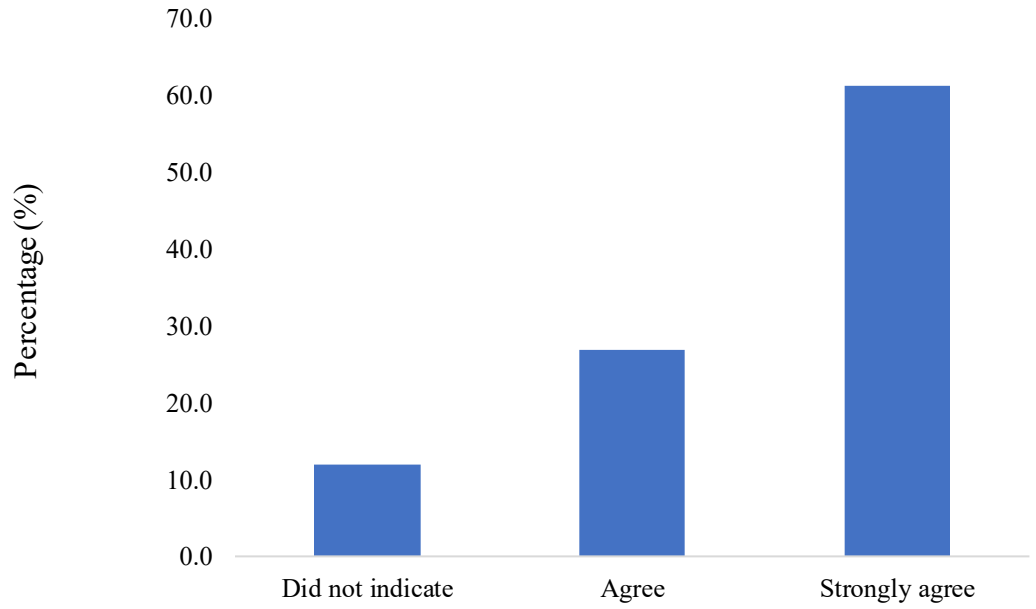

Figure 37: Perceptions of the Impact of Poor Storage on Fish Taste and Safety.

5.14 Staff Training in Fish Hygiene and Cold Chain Handling

Respondents indicate that cold storage improves the market value of fish, with 32.8% agreeing and 22.4% strongly agreeing that proper storage positively affects fish pricing. A smaller proportion disagrees (9.0%) or strongly disagree (7.5%), while 28.4% do not indicate their opinion (Fig. 38). This shows that a majority of stakeholders recognize the economic benefits of cold storage, while a substantial portion remains uncertain or neutral, which continues to influence how businesses invest in cold chain facilities, manage fish quality, and set pricing strategies. The results also highlight the ongoing importance of staff training in fish hygiene and cold chain handling, as proper management of storage directly contributes to maintaining fish quality and enhancing market value.

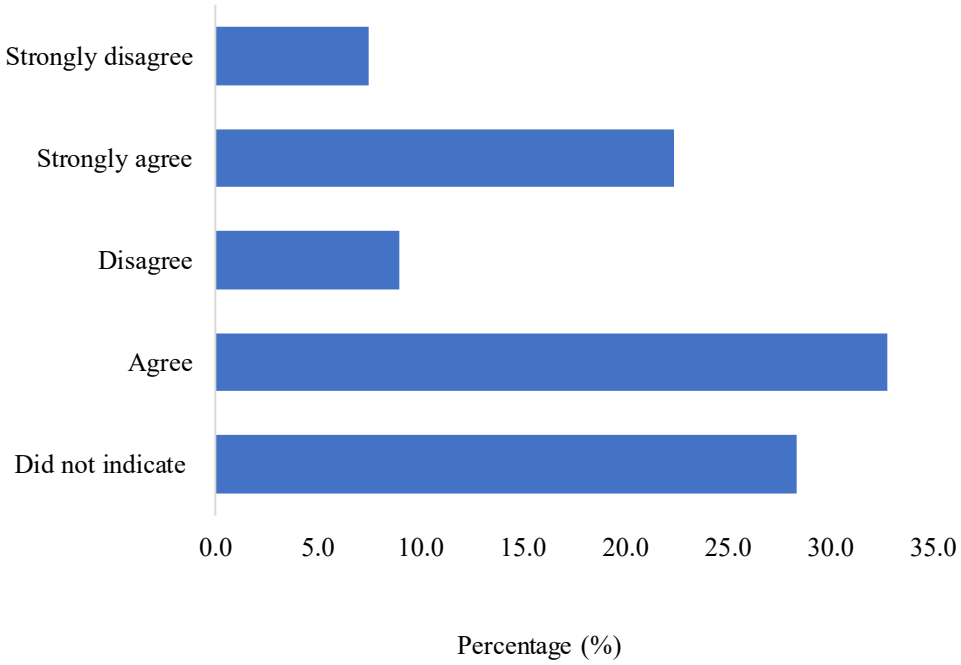

Figure 38: Perceptions of Cold Storage on Fish Market Value

5.15 Enforcement of Food Safety Regulations in Business Environment

Respondents report mixed perceptions of food safety regulation enforcement in their business environment. Nearly half (49.3%) are not sure whether regulations are enforced, showing a significant level of uncertainty or lack of visibility regarding regulatory oversight. About 25.4% agree and 13.4% strongly agree that food safety regulations are enforced, together indicating that 38.8% of stakeholders perceive some level of enforcement. In contrast, 4.5% disagree and 7.5% strongly disagree, reflecting a smaller but notable group that perceives weak enforcement (Fig. 39). These ongoing mixed perceptions, with uncertainty being the most dominant response, continue to shape how businesses implement food safety practices, manage compliance, and interact with regulatory authorities, highlighting the need for clearer communication and more visible enforcement across the sector.

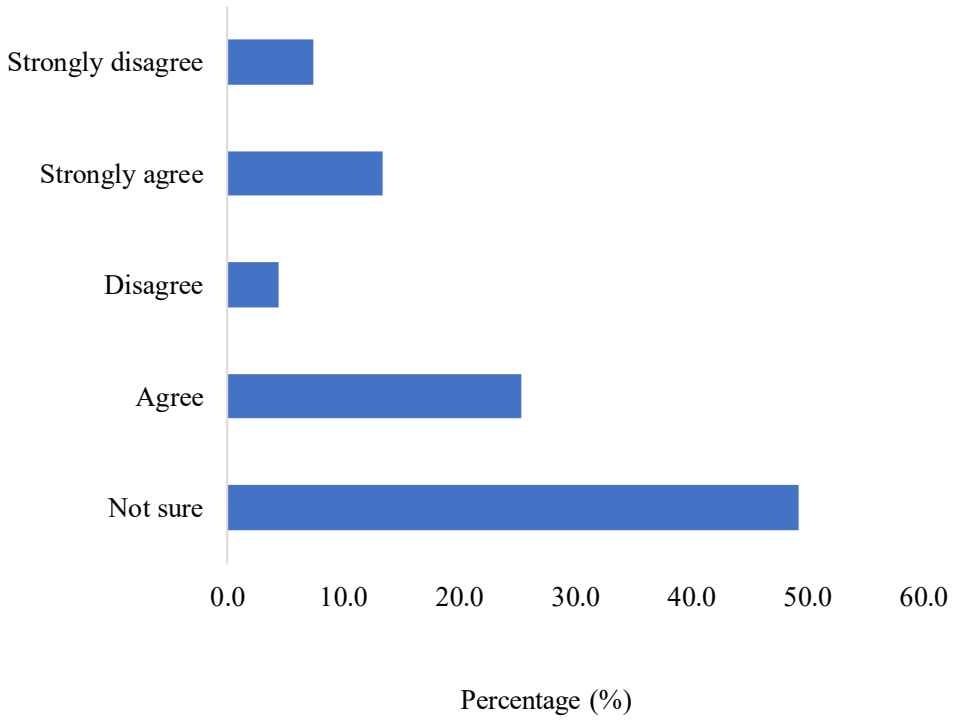

Figure 39: Perceptions of Food Safety Regulation Enforcement Among Businesses

5.16 Training Received on Cold Chain Management or Food Safety

Among the surveyed businesses, the majority (67.2%) report that neither they nor their staff have received any training on cold chain management or food safety, while 32.8% indicate that they or their staff have undergone some form of training in these areas (Fig. 40). This shows a substantial gap in capacity building among stakeholders, which continues to influence how businesses manage cold storage, maintain product quality, and comply with food safety standards. The ongoing lack of training emphasizes the need for expanded capacity-building programs to strengthen cold chain practices, hygiene, and food safety compliance across the sector.

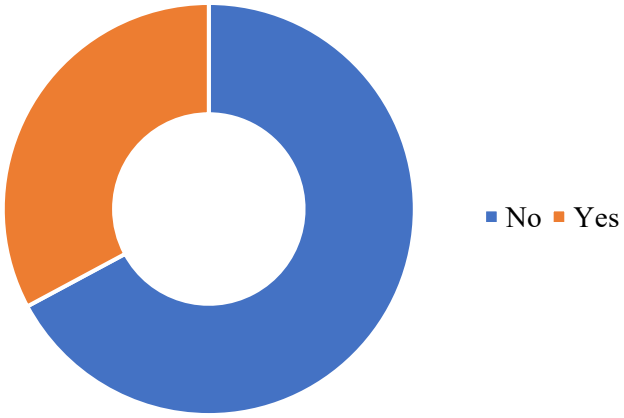

Figure 40: Training in Cold Chain Management and Food Safety Among Businesses

5.16.1 Provider or Programme of Cold Chain or Food Safety Training

Among respondents who reported a training source (n = 6), support is mainly provided through development projects. WorldFish (including ProFish Blue) and ZATP each account for 33.3%, while public health programmes and other donor-supported initiatives (USAID, FEd Zambia, EDGE, ProFish Blue) each contribute 16.7% (Table 20). This indicates that cold chain and food safety training is largely project-driven rather than institutionalised, affecting its consistency, coverage, and long-term sustainability.

Table 20: Sources of Cold Chain and Food Safety Training Among Businesses.

Training Provider / Programme	Frequency	Percent (%)
WorldFish (including Profish Blue Project)	2	33.3
Zambia Agribusiness and Trade Project (ZATP – incl. Phase 2)	2	33.3
Public Health (Food Safety–related training)	1	16.7
USAID / FEd Zambia / EDGE / Profish Blue (long-term training programmes)	1	16.7
Total	6	100.0

5.17 Climate stressors are increasing pressure on already fragile cold chain systems

The survey (n = 67) shows that climate-related factors significantly affect cold chain operations. Increased ambient temperatures are the most reported challenge, with 58.2% rating it as major and 10.4% as very major (Table 21). Power outages linked to extreme weather are also widespread, affecting operations for 41.8% (major) and 13.4% (very major) of respondents. Transport delays due to floods or road damage are similarly important, rated as major by 28.4% and very major by 11.9%. Although some respondents view these issues as minor or not significant, the overall pattern shows that climate stressors consistently disrupt cold storage, transport planning, and fish quality management, underscoring the importance of energy reliability and infrastructure resilience in cold chain systems.

Table 21: Climate-Related Challenges Affecting Cold Chain Operations

Climate-related challenge	Not indicated	Not a challenge	Minor challenge	Moderate challenge	Major challenge	Very major challenge
Increased ambient temperatures	9.0%	3.0%	7.5%	11.9%	58.2%	10.4%
Power outages due to extreme weather	16.4%	6.0%	11.9%	10.4%	41.8%	13.4%
Transport delays due to floods or road damage	35.8%	4.5%	11.9%	7.5%	28.4%	11.9%

5.18 Capacity gaps persist due to limited and project-driven training systems

The survey (n = 67) shows that climate-related factors significantly affect cold chain operations. Increased ambient temperatures are the most reported challenge, with 58.2% rating it as major and 10.4% as very major (Table 22). Power outages linked to extreme weather are also widespread, affecting operations for 41.8% (major) and 13.4% (very major) of respondents. Transport delays due to floods or road damage are similarly important, rated as major by 28.4% and very major by 11.9%. Although some respondents view these issues as minor or not significant, the overall pattern shows that climate stressors consistently disrupt cold storage, transport planning, and fish quality management, underscoring the importance of energy reliability and infrastructure resilience in cold chain systems.

Table 22: Support Needs to Improve Fish Storage and Transport Capacity

Support / Intervention Needed	Frequency	Percent (%)
Access to affordable cold storage units	35	52.2
Technical training on fish preservation and hygiene	29	43.3
Subsidised power or fuel	24	35.8
High quality fish supply	22	32.8
Improved road or transport infrastructure	6	9.0
Access to solar powered or alternative energy systems	3	4.5

5.19 Interest in Partnerships to Improve Cold Chain Systems

Among the respondents, a majority express interest in partnerships to improve cold chain systems, with 67% indicating "Yes". About 25% are not interested, while 7% are uncertain or respond "Maybe" (Fig. 41) This shows a strong willingness among stakeholders to engage in collaborative efforts aimed at enhancing cold storage and transport infrastructure for fish products, which continues to influence how businesses consider joint investments, share resources, and strengthen capacity across the value chain.

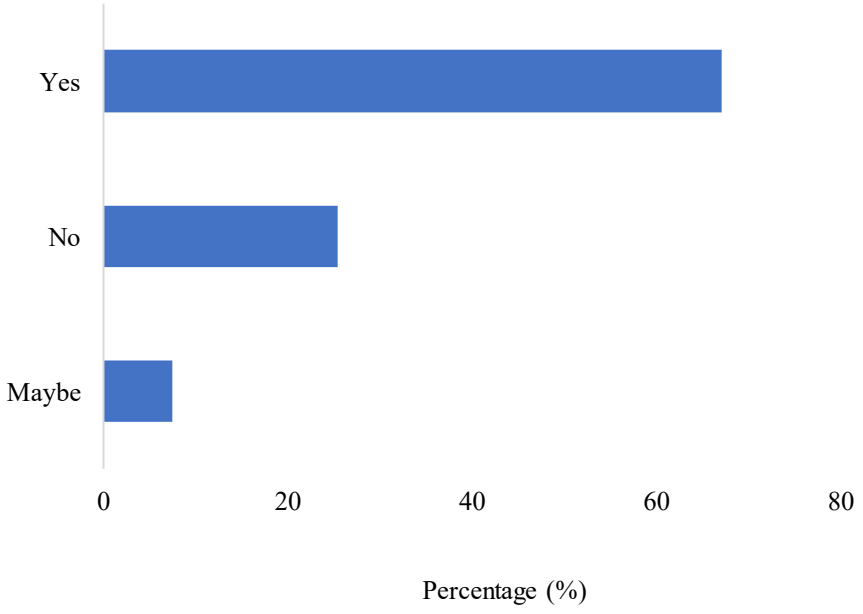

Figure 41: Interest in Partnerships to Improve Cold Chain Systems

5.20 Key Financial and Operational Challenges in Cold Chain Management for Fish Businesses

Respondents identified several interrelated financial and operational constraints affecting cold chain management (Table 23). The most prominent is the lack of business advisory services, rated as a major challenge by 65.7% and a very major by 16.4%. Limited access to affordable financing follows closely, with 62.7% and 19.4% rating it as major and very major, respectively. High costs of refrigeration equipment are also significant (47.8% major; 40.3% very major), alongside inconsistent electricity supply (61.2% major; 23.9% very major). Inflation and high interest rates are less dominant but still important (29.9% major; 22.4% very major). Overall, these results show that cold chain performance is shaped by a combination of financial, energy, and advisory constraints that jointly influence investment and operational decisions. This points to the need for integrated responses combining advisory support, improved financing mechanisms, cost-effective and energy-efficient technologies, and shared infrastructure models to strengthen cold chain systems and post-harvest outcomes. Additional challenges reported by farmers are detailed in Annex Table 1.

Table 23: Financial and Operational Challenges Affecting Cold Chain Management Among Fish Businesses

Challenge	Major (%)	Minor (%)	Moderate (%)	Very major (%)
Limited access to affordable financing	62.7	11.9	6.0	19.4
High cost of refrigeration equipment	47.8	9.0	3.0	40.3
Inflation and high interest rates	29.9	11.9	20.9	22.4
Inconsistent electricity supply	61.2	3.0	7.5	23.9
Lack of business advisory services	65.7	7.5	9.0	16.4

5.21 Support Needed to Enhance Investment Capacity

Access to credit or low-interest loans is the most common form of support among offtakers, reported by 91.0% of respondents. Equipment leasing or rent-to-own arrangements and training support are each reported by 50.7%, while 40.3% have access to public or shared infrastructure, and only 11.9% report receiving government subsidies (Table 24). This shows that financial

mechanisms, particularly credit, dominate existing support systems compared to infrastructure or direct subsidies, with many respondents benefiting from multiple types of assistance.

Overall, the findings indicate that investment support in the cold chain sector is mainly driven by credit-based mechanisms, with supplementary roles played by leasing, training, and shared infrastructure. Strengthening cold chain investment will therefore require prioritising accessible and flexible financing, while complementing this with equipment access models, capacity building, and expanded public support to improve uptake and sustainability among small and medium-scale businesses.

Table 24: Forms of Support Enhancing Investment in Cold Chain Systems Among Fish Businesses.

Support Type	Frequency	Percent (%)
Access to credit or low-interest loans	61	91.0
Equipment leasing / rent-to-own	34	50.7
Training	34	50.7
Public / Shared infrastructure	27	40.3
Government subsidies	8	11.9

Note: Percentages exceed 100% because facilities could receive multiple types of support

5.22 Business Models Supporting Cold Chain Investment

Among the offtakers surveyed, the most common business model is collaboration with other offtakers or aggregators (68.7%), followed by joint ventures with aquaculture offtakers (50.7%) (Table 25). Smaller proportions report integration with other agricultural value chains (14.9%), while cooperative or shared storage arrangements and public-private partnerships each account for 11.9%. Only 1.5% rely on individual asset ownership, such as buying fridges.

Overall, the results show that cold chain investment and operations are largely driven by collaborative and partnership-based models rather than individual ownership. Many offtakers also combine multiple models, indicating flexible strategies to share resources, reduce investment risk, and improve operational efficiency. This highlights the importance of

strengthening joint ventures, aggregation systems, and cooperative storage arrangements to support more scalable and resilient cold chain systems.

Table 25: Business Models Supporting Cold Chain Investment Among Fish Businesses

Business model	Frequency	Percent (%)
Collaboration with other offtakers or aggregators	46	68.7
Joint ventures with aquaculture farmers	34	50.7
Integration with other agri value chains	10	14.9
Cooperative or shared storage	8	11.9
Public private partnerships	8	11.9
Buying fridges	1	1.5

5.23 Willingness to Join a Regional Cold Chain Network

Among the respondents, a majority (76%) expressed willingness to join a regional cold chain network, while 24% indicated they were not willing (Fig. 4). This demonstrates a strong interest among fish businesses in collaborative efforts aimed at strengthening cold chain systems, facilitating knowledge exchange, and enhancing operational efficiency across the region. The high willingness to participate in a regional network highlights the potential for collective action and collaboration to improve cold chain management. Development initiatives and policymakers can leverage this interest by establishing regional platforms or networks that promote shared learning, joint investment, and coordinated infrastructure use. Encouraging participation in such networks can strengthen linkages among businesses, enhance resource sharing, and support more resilient and integrated cold chain systems across the fish value chain.

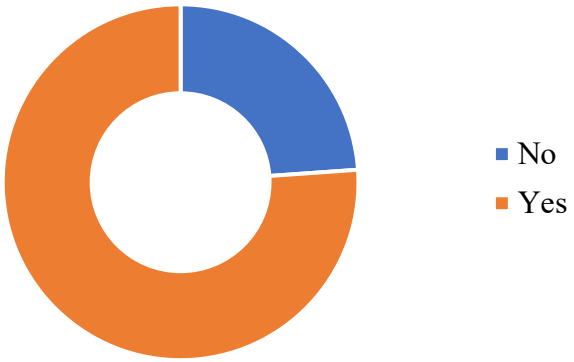

Figure 42: Willingness of Fish Businesses to Join a Regional Cold Chain Network

6 RECOMMENDATION

Based on the combined findings from producers, institutions, and offtakers, the following integrated recommendations are proposed to strengthen cold chain development and post-harvest management in the aquaculture sector:

1. **Expand and Diversify Cold Chain Infrastructure**: The widespread reliance on ice boxes (74.6%) and limited access to cold rooms (23.9%) and insulated transport (7.5%) contributes to short storage durations and high spoilage risks, particularly in a sector dominated by small-scale actors. This constrains product quality, income stability, and market expansion. To address this, investment should focus on scalable shared cold chain systems, including solar-powered cold hubs, cooperative cold rooms, and mobile refrigerated units. Implementation should be led by the Ministry of Fisheries and Livestock with local authorities, cooperatives, and private investors, prioritising high-activity trading and production zones such as Lusaka and Kitwe. A useful reference is Kenya's county-level fish cold hubs, which reduced post-harvest losses. Initial steps should focus on piloting shared facilities in key urban markets, followed by phased expansion to production clusters.

2. **Strengthen Access to Affordable Financing**: High costs of refrigeration equipment (over 87% reporting major constraints) and limited access to affordable finance significantly restrict investment in cold chain infrastructure. This limits the adoption of improved storage technologies and reinforces reliance on short-term, low-capacity systems. To address this, tailored financial instruments such as low-interest loans, leasing schemes, blended finance, and revolving funds should be expanded specifically

for cold chain investment. Implementation should involve commercial banks, development finance institutions, and government-led agricultural financing programmes. Uganda's Agricultural Credit Facility provides a relevant example of subsidised financing for agro-processing and cold storage. The next step is to establish a dedicated cold chain financing window within existing agricultural credit schemes, beginning with SMEs in high-demand districts.

3. **Promote Cooperative, Partnership-Based, and Network Models**: Although collaboration among offtakers is relatively strong (68.7%), infrastructure ownership remains fragmented, with nearly half lacking cold chain access. This contributes to inefficiencies in storage, transport, and market coordination. The recommended solution is to formalise cooperative storage systems, aggregation networks, and joint investment models supported by public–private partnerships. Implementation should be led by cooperatives, local councils, and private aggregators, with support from NGOs and development partners. Ghana's cooperative fish cold storage model demonstrates how shared infrastructure can reduce losses and improve bargaining power. Next steps include mapping existing informal clusters and upgrading them into formalised cold chain network nodes.

4. **Enhance Training, Extension, and Business Advisory Services**: Despite high awareness of spoilage, 67.2% of businesses report no training in cold chain or food safety, indicating a major capacity gap. This limits proper handling practices, operational efficiency, and compliance with quality standards. The recommended solution is to integrate practical cold chain, food safety, and hygiene training with business advisory services covering financial planning and operations. Implementation should be led by universities, fisheries institutes, and extension systems in collaboration with programmes such as WorldFish and ZATP. Zambia's Farmer Field Business School model provides a useful example of integrating technical and business training. Next steps include embedding cold chain modules into extension services and linking training participation to access to finance and infrastructure support.

5. **Leverage Universities and Research Institutions as Core Partners**: Although universities and research institutions contribute to training and research, their involvement in direct cold chain innovation and deployment remains limited. This slows the adaptation of cost-effective and climate-resilient technologies suited to local

conditions. The solution is to position universities as applied innovation and demonstration hubs for cold chain technologies, including pilot systems, curriculum integration, and field testing. Implementation should be led by institutions such as the University of Zambia and Palabana University in partnership with government and development agencies. Tanzania's Sokoine University cold room pilot demonstrates how academic institutions can support practical technology transfer. Next steps include establishing demonstration cold chain units within universities and linking them to private sector scaling pathways.

6. **Improve Energy Reliability and Climate Resilience:** Unreliable electricity supply (over 89% reporting major or very major challenges) and increasing ambient temperatures significantly disrupt cold chain operations, increasing spoilage and operational costs. These constraints weaken investment confidence and reduce system reliability. The solution is to scale renewable and hybrid energy systems, particularly solar-powered cold storage and backup energy solutions. Implementation should involve the Ministry of Energy, private solar providers, and development partners through public–private partnerships. Rwanda's solar cold chain hubs offer a relevant example of climate-resilient infrastructure supporting rural value chains. Next steps include piloting solar-powered cold rooms in off-grid and high-loss areas, followed by phased scaling through PPP models

7. **Increase Awareness and Adoption of Food Safety Standards**: Although awareness of spoilage is high, almost half of stakeholders are uncertain about food safety enforcement, limiting consistent compliance and access to premium markets. This creates variability in quality assurance practices across the value chain. The solution is to simplify food safety standards and integrate them into routine business operations through training and extension systems. Implementation should be led by regulatory authorities in collaboration with traders' associations and training institutions. South Africa's simplified HACCP-based compliance system for small-scale fisheries offers a useful model for improving adoption. Next steps include developing simplified compliance tools and embedding them into licensing, training, and market inspection systems.

8. **Support Integrated, Multi-Dimensional Intervention Packages**: Cold chain challenges are interconnected, involving infrastructure, finance, energy, and skills

simultaneously, meaning isolated interventions are insufficient. This fragmentation limits the effectiveness of sector investments. The solution is to design integrated support packages combining financing, infrastructure, training, advisory services, and market linkages. Implementation should be coordinated by government with development partners and private sector actors through structured value chain programmes. Ethiopia's integrated agricultural transformation programmes provide a strong example of bundled support systems. Next steps include piloting integrated cold chain packages in selected provinces before scaling nationally.

9. **Strengthen Information Sharing and Outreach**: Limited awareness of available support programmes reduces uptake of financing, training, and infrastructure opportunities across the value chain. This weakens coordination and slows sector development. The solution is to establish centralized cold chain information and coordination platforms that improve visibility of services and support mechanisms. Implementation should involve government ministries, ICT agencies, and industry associations through digital platforms and extension networks. India's eNAM platform illustrates how digital systems can improve access to market and support information. Next steps include developing a national cold chain information portal linked to district extension offices and stakeholder networks.

7 CONCLUSION

This study provides an integrated understanding of cold chain management within the aquaculture value chain in Zambia by examining the perspectives of producers, institutions, and offtakers. Across all stakeholder groups, the findings demonstrate that aquaculture and fish marketing are largely driven by small- and medium-scale actors operating within a dynamic but resource-constrained environment. Production is dominated by pond-based systems managed by experienced farmers, while marketing and distribution are led by privately owned butcheries, fishmongers, and processors that serve as critical links between producers and consumers. Together, these actors shape fish quality, market access, and income stability across the value chain.

Access to cold chain infrastructure emerges as a central determinant of post-harvest performance. While some stakeholders utilize basic cold storage solutions such as ice boxes and small freezers, access to advanced infrastructure including walk-in cold rooms, refrigerated

transport, and reliable energy systems remains uneven. As a result, rapid turnover and short storage durations are common practices across both production and marketing nodes. Stakeholders across the value chain demonstrate strong awareness of spoilage, food safety, and quality implications, alongside confidence in identifying deterioration, indicating that infrastructure and affordability constraints play a more influential role than knowledge gaps alone.

Financial, operational, and institutional factors collectively shape cold chain investment and management. High equipment costs, energy reliability, access to affordable financing, business advisory services, and climate-related pressures influence decision-making for farmers and offtakers alike. Institutional actors contribute significantly through training, research, and advisory support, while universities and research institutions play a key role in innovation, skills development, and evidence generation. However, direct investment support and coordinated infrastructure development remain limited, highlighting opportunities for more integrated programming.

Encouragingly, strong willingness to engage in cooperative arrangements, partnerships, and regional cold chain networks is evident across stakeholder groups. Farmers, institutions, and offtakers consistently express interest in shared infrastructure, joint investment models, and collaborative platforms that reduce individual risk and enhance efficiency. Preferences for blended investment approaches combining private ownership, financial support, training, and partnerships underscore the value of multi-dimensional interventions. Overall, the findings indicate substantial potential to strengthen aquaculture value chains through coordinated cold chain development that integrates infrastructure, financing, capacity building, energy solutions, research, and institutional collaboration, thereby enhancing post-harvest efficiency, market participation, and sector resilience.

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ANNEX

1. RESEARCH APPROACH AND METHODS

To achieve the objectives, a mixed-methods research design was employed, combining both primary and secondary data collection approaches. This design ensured a holistic understanding of the cold chain infrastructure landscape, particularly for small-scale aquaculture enterprises in Zambia, most of whom cultured indigenous or locally available tilapia and non-tilapia fish species.

1.1 Primary Data Collection

Primary data were gathered through field visits, structured questionnaires, and key stakeholder consultations. These activities generated first-hand insights into existing cold chain practices, infrastructure availability, post-harvest handling techniques, and operational challenges faced by small-scale fish farmers and aquaculture cooperatives.

1.2 Structured Questionnaires

These were administered to smallholder fish farmers, hatchery operators, aquaculture cooperatives, and cold storage operators. The data covered current post-harvest handling methods, cold chain equipment use, transport systems, storage gaps, and common losses incurred.

2. Gender of respondents

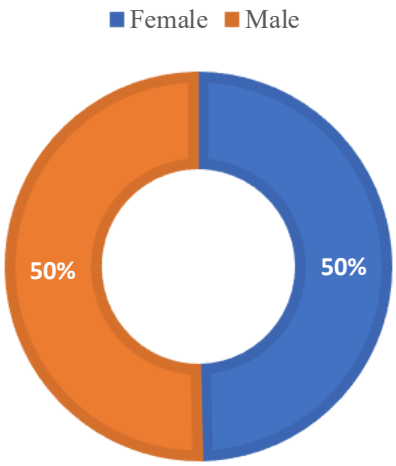

Figure 1: Gender of respondents

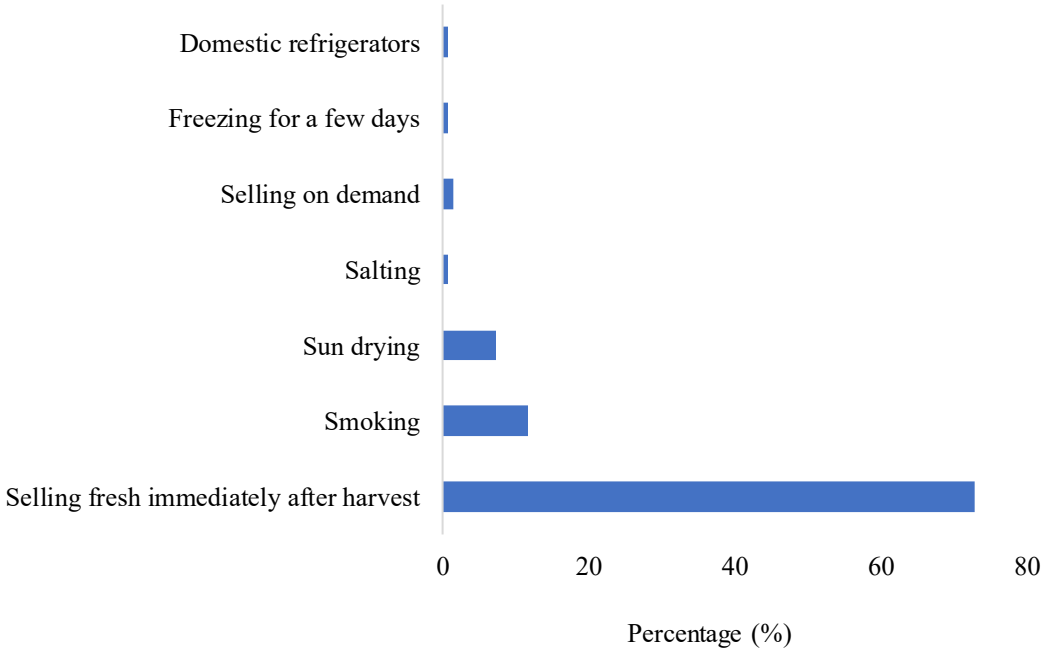

Figure 2: Various fish preservation methods employed by farmers

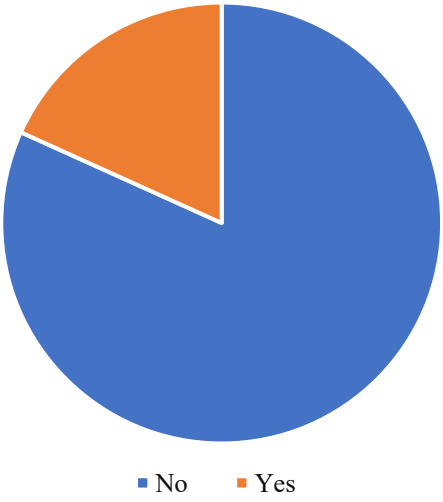

Figure 3*: Percentages of respondents with and without access to a cold facility*

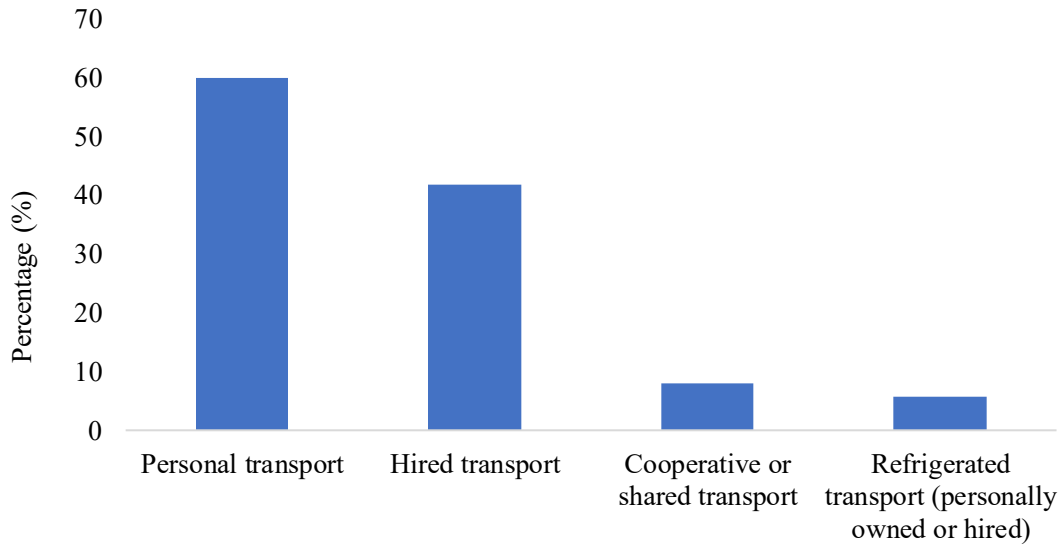

Figure 5: How fish is transported to the market

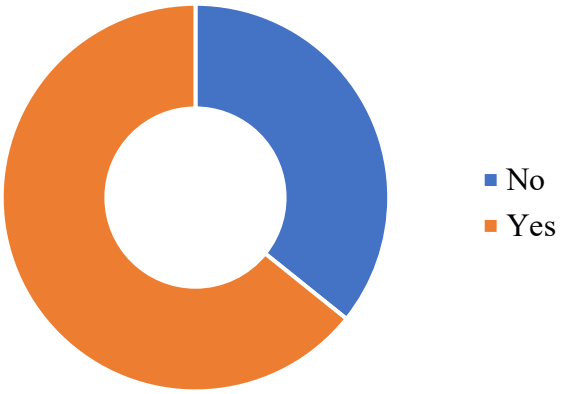

Figure 6: Proportion of Fish Farmers Who Have Received Post-Harvest Handling Training

3. Business Scale

Among the surveyed business outlets, the majority are small-scale operations, accounting for 79.1% of respondents, while 20.9% are medium-scale businesses. The prevalence of small-scale enterprises shows that most stakeholders operate with limited resources, lower production capacity, and smaller market reach, while medium-scale businesses remain relatively few. This structure continues to influence how stakeholders manage operations, access financing, adopt improved storage or processing technologies, and participate in value chain activities, shaping the overall dynamics of the meat and fish sector.

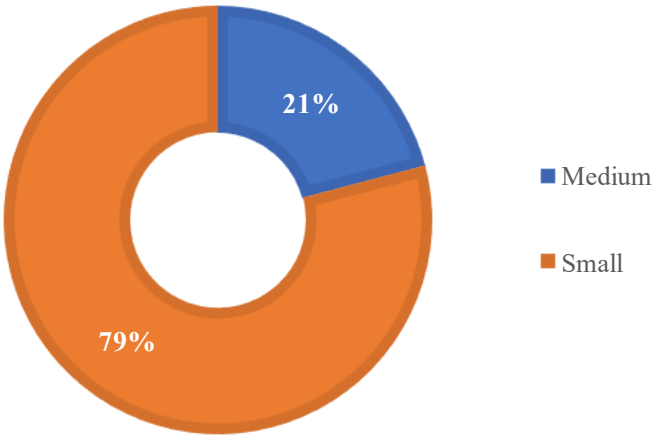

Figure 7: Scale of Business Operations Among Meat and Fish Value Chain Stakeholders

3.2 Additional Comments and Recommendations (Offtakers).

Among respondents, 24% did not provide specific comments. The most frequently cited need was training (33%), particularly technical and practical guidance on cold chain management (Table 1). Financial support was highlighted by 12%, while 10% emphasized improved infrastructure such as refrigeration, solar powered systems, and storage facilities. Smaller proportions mentioned cooperative or commercial cold chain models (6%), knowledge sharing initiatives such as exposure visits (5%), general institutional support (6%), income generation (1%), and positive feedback on existing programmes (3%).

Overall, the responses point to four main priorities: training, financial support, infrastructure development, and knowledge exchange. This indicates that strengthening cold chain systems requires a combined approach that builds technical capacity, improves access to finance, and expands infrastructure, particularly energy efficient and solar based solutions, while also promoting cooperation and learning platforms to support collective action across the value chain.

Table 1: Additional Support Needs and Recommendations from Fish Businesses

Recommendation	Frequency	Percent (%)
No comment / Not specified	16	23.9
More training / trainings	22	32.8
Financial support / grants / loans	8	11.9
Support for cold chain infrastructure (storage, refrigeration, solar energy)	7	10.4
Engagement in commercial cold chain business / cooperative support	4	6.0
Opportunities for exposure / learning from others	3	4.5
Income generation	1	1.5

Recommendation	Frequency	Percent (%)
General support / “continue supporting us” / “we need support”	4	6.0
Positive feedback / program appreciation	2	3.0