COLD CHAINS FOR OCEAN COMMUNITIES

PLAYBOOK FOR PROJECT DEVELOPERS AND INVESTORS

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VERSION

This document presents the first version of this technical report. It is intended as an initial release and may be updated as additional insights, analyses, and refinements become available.

We welcome feedback, corrections, and suggestions that may improve future editions of this report. Please direct all comments to bas.hetterscheid@wur.nl.

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EXECUTIVE SUMMARY

Fisheries around the world and especially in the Southwest Indian Ocean (SWIO) region are at a pivotal moment. Coastal communities rely heavily on marine resources for food security and livelihoods, yet they are facing intensifying pressures from climate change, resource depletion, unsustainable harvesting and high food loss in supply chains. At the same time, within the development sector there is increasing attention for cooling solutions, driven by sustainable development goals (such as SDG 2, 7, 12.3 and the Montreal Protocol). Cold chain technologies can play a critical role in helping to reduce losses in the value chain and improve product quality to enable access to higher-value consumer markets, contributing to increased incomes and improved livelihoods. However, many cold chain investments in the region underperform, often due to challenges in project planning, governance, market linkages, technology choices, operating models, or energy and water reliability, amongst others, leading to poorly run programmes and stranded assets.

The goal of this playbook is to measurably increase the percentage of commercially viable and ecologically sustainable cold chain businesses globally. Our primary audience are entrepreneurs and development agencies, but also wider ecosystem partners, such as technology providers, banks and investors, government institutions, NGOs, cooperatives, beach management units (BMUs)[1] and research organizations. Each of these stakeholders play a distinct and important role in helping drive investment and long-term, sustainable cold chain engagements. To ensure local impact, this playbook specifically targets small-to-medium scaled community fishery projects with a primary focus on captured fisheries; however, many of the strategies, practices and technical solutions will equally apply to aquaculture investments.

1 Note: Community-based fisheries co-management organizations operate under different names across the Southwest Indian Ocean (SWIO) region. For example, they are referred to as locally managed marine areas (LMMAs) in Madagascar and as Community Conservation Projects (CCPs) in Mozambique. For simplicity and consistency, this report uses the term Beach Management Unit (BMU) to refer to all such community-based management structures, regardless of their local designation.

The playbook provides a practical and comprehensive guide for designing, financing and operating cold chain solutions to help projects be commercially viable and sustainable. It emphasizes that cold chain projects need to be founded in both the local context but also the full fishery ecosystem, from resource availability and climate resilience to global market dynamics, (community) governance and long-term operational capacity.

By aligning technical, commercial, operational and environmental considerations (e.g., reducing fishing pressure), this resource aims to help stakeholders design cold chain interventions that generate long-term value, not only for individual enterprises, but for the broader fisheries ecosystem and the coastal communities whose livelihoods depend on it.

This playbook has three different sections with eight chapters, which walk entrepreneurs, project developers, banks and investors through the different steps to ensure cold chain investments are commercially viable and generate sustainable profits.

SECTION 1
VIABILITY OF THE GEOGRAPHIC LOCATION

Chapter 1: Assessing production capacity & seasonality – This chapter looks at the fish supply chain and the importance of assessing the opportunity at the community and ecosystem level. This includes verifying sustainable fish stocks, species mix and seasonality as the basis for any economic feasibility assessment for long-term, sustainable cold chain operations.

Chapter 2: Understanding the market opportunity – Once the fish supply is deemed sufficient and sustainable, the next basic requirement is the existence of accessible demand. For any development, it is critical to understand all the key market players while also identifying reliable demand.

Chapter 3: Understanding the availability of energy and water – Reliable energy and water systems are critical to successful cold chain operations and can often represent a key challenge in the SWIO region. A rapid assessment of grid reliability, solar or hybrid feasibility, load requirements, and water quality and availability is sufficient for most projects. For larger or more complex interventions, a more comprehensive assessment is recommended to ensure that infrastructure can operate consistently and safely.

SECTION 2
INTERVENTION DESIGN

Chapter 4: Selecting the right cold chain technology – Cold chain technology must consider fish volumes, species characteristics, quality needs, handling practices and local context and conditions while avoiding both oversizing and undersizing capacity.

Chapter 5: Defining ownership, governance, and operational model – Selecting the appropriate ownership and governance structures, whether community-led, private, public or hybrid, often significantly impacts the success probabilities of cold chain projects. Many factors impact the optimal structure (e.g., objectives, community context, policies, financing and scale, and the choice will impact accountability, transparency, stakeholder alignment and effective decision-making.

Chapter 6: Ensuring financial viability – A detailed financial projection model is critical to determine upfront if the cold chain project is commercially viable and sustainable. Assumptions on volumes, market pricing, capital and operating expenditures including maintenance costs, amongst other key factors, must all be grounded in business realities. Understanding the project's economic feasibility, possible scenarios and financing needs early will support sound financial management, and is needed to make the investment case to financiers.

SECTION 3
PROCUREMENT AND IMPLEMENTATION GUIDANCE

Chapter 7: Procuring the cold chain technology, installation and ongoing maintenance – Successful cold chain deployment depends on developing clear technical specifications to find the right supplier and source high-quality equipment. Identifying and engaging reliable suppliers help guarantee 1) asset investments perform to specifications and 2) performance can be maintained over the expected lifespan. In addition, correct installation is important to ensure the technology delivers its best performance, and regular, proactive maintenance as well as access to spare parts, are critical to sustain performance. Personnel should be trained to operate the technology, applying standard operating procedures.

Chapter 8: Measuring and communicating impact – Measuring and communicating impact is important to intentionally manage the outcomes achieved, gain stakeholder buy-in and create intelligence to inform future efforts. It is important to monitor the effect of cold chain investments on fishing dynamics, including its effect on fishing efforts, to ensure that improvements to cold chains do not generate unsustainable pressure on fish stocks. Indicators need to be defined against the objectives, ideally across economic, social and environmental outcomes; then, insights can be used to improve performance, strengthen compliance and demonstrate value to funders, partners and local communities.

Project Checklist

VIABILITY OF THE GEOGRAPHIC LOCATION

ASSESSING PRODUCTION CAPACITY

- [ ] Are the average and seasonal fish yields sufficient to justify investment?
- [ ] Is the quality profile of landed fish sufficient to meet market demand?
- [ ] Are measures in place to ensure investment will not lead to overfishing?

UNDERSTANDING THE MARKET OPPORTUNITY

- [ ] Is market demand sufficient to absorb projected volumes at viable prices?
- [ ] Are there reliable off-takers with clear volume, quality and pricing terms?
- [ ] Are the logistics and food safety requirements feasible?

UNDERSTANDING THE AVAILABILITY ENERGY AND WATER

- [ ] Is the energy supply reliable for uninterrupted cold chain operations?
- [ ] Are energy costs sustainable at the targeted operating scale?
- [ ] Is the water supply reliable and compliant with food-safety requirements

INTERVENTION DESIGN

SELECTING THE RIGHT COLD CHAIN TECHNOLOGY

- [ ] Does the technology meet target temperature and quality requirements?
- [ ] Is the technology fit for local operating conditions and capabilities?
- [ ] Can the technology be operated reliably at required scale and seasonality?

DEFINING OWNERSHIP, GOVERNANCE AND OPERATIONAL MODELS

- [ ] Is ownership clearly defined with aligned risk and return incentives?
- [ ] Is governance strong enough to ensure accountability and performance?
- [ ] Is the operating model executable with local capabilities and partners?

ENSURING FINANCIAL VIABILITY

- [ ] Do projected revenues cover all the costs, and ensure healthy cashflows?
- [ ] Is break-even achievable at realistic volumes and utilization?
- [ ] What is the payback period on asset investments?
- [ ] Is the financing structure aligned with cashflows, seasonality and risk?

PROCUREMENT AND IMPLEMENTATION GUIDANCE

PROCURING THE COLD CHAIN TECHNOLOGY, INSTALLATION AND ONGOING MAINTENANCE

- [ ] Are procurement specifications clear, complete and enforceable?
- [ ] Are suppliers reliable in delivery, installation and after-sales support?
- [ ] Is the procurement approach aligned with quality, cost, timelines and risk?
- [ ] Is long-term maintenance available, including technicians and spare parts?
- [ ] Are lifecycle maintenance and replacement costs fully planned and financed?

MEASURING AND COMMUNICATING IMPACT

- [ ] Is there a MEL framework with clear baselines, KPIs and accountability?
- [ ] Is impact data reliable enough for operational decision-making?
- [ ] Is impact communicated clearly to support funding, trust and scale?

BACKGROUND

With an estimated 2.4 billion individuals, largely women and residents of rural areas, not having consistent access to nutritious, safe and sufficient food, cold chains are critical to closing the nutrient gap.[2,3] The blue economy represents a key opportunity to address this challenge in the Southwest Indian Ocean (SWIO) region. However, while regional demand for fish grows, supply lags behind, and per capita consumption is projected to decline as population growth outpaces production.[4] This indicates an opportunity to invest in commercial, sustainable and locally anchored fishery value chains.

Fish, however, are highly perishable and susceptible to post-harvest losses at every step of the value chain, including transportation, storage and processing.[5] Global fish loss is estimated to be between 30-35% across most regions in the world, particularly in developing countries, due to technical, financial, infrastructural and managerial constraints.[3] In developing regions, poor handling and limited cold chain access result in lost income and reduced food availability and quality. Investing in localized cooling technologies, such as solar-powered freezers and ice flake machines can reduce spoilage, increase shelf life and improve market prices while supporting food security and sustainable livelihoods.

2 FAO. (2023). The state of food security and nutrition in the world.

3 UNEP and FAO. (2022). Sustainable food cold chains: Opportunities, challenges and the way forward.

4 FAO. (2022). The state of world fisheries and aquaculture (SOFIA).

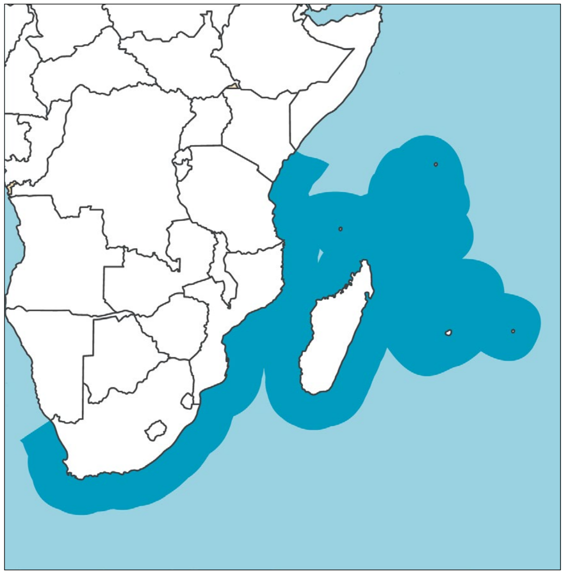
5 FAO. (2023). The small-scale fisheries and energy nexus.

In the development sector, there is increased attention for cooling solutions to meet sustainable development goals (SDGs). For example, through SDG 7 on access to sustainable energy there is focus on off-grid cooling, through the Montreal Protocol in climate-friendly refrigerants and via SDG 12.3 on reducing food loss and waste as intervention pathway. Despite increased global interest in cold chains, many investments in cold chains and in fisheries in the SWIO region show mixed results. Many have failed due to weak business cases, poor governance, lack of market access, overfishing and even lacking access to spare parts.[6,7]

This ***Cold Chains for Ocean Communities Playbook*** seeks to provide practical guidance for the setup of fishery cold chain projects. Its primary audience are entrepreneurs, development agencies, banks and investors, but the guidance is equally relevant to wider ecosystem partners such as technology providers, government institutions, NGOs, cooperatives, beach management units (BMUs) and research organizations, each of whom plays a distinct role in driving sustainable cold chain investments. The playbook discusses a number of critical topics that need careful consideration from the onset, taking the best practices and lessons learned from past efforts, therewith contributing to the design of more successful and sustainable cold chain projects within the fishery value chains in the SWIO region and beyond.

6 WWF & Open Capital Advisors. (2023). Cool blue food: Harnessing aquaculture for sustainable food systems.

7 Efficiency for Access. (2023). Keep it cool: Harnessing cold storage to reduce food loss and support sustainable food systems in emerging economies.



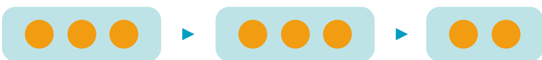
Southwest Indian Ocean (SWIO) Region

Countries in the SWIO region include Kenya, Tanzania, Mozambique, South Africa, and Madagascar, plus island nations Seychelles, Mauritius, and Comoros.

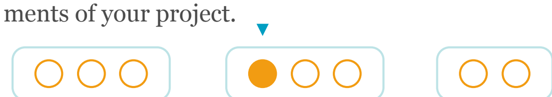
How to use this playbook

This playbook is a practical resource and thought partner for anyone developing a fishery cold chain project in the SWIO region and beyond. As a reader, you can either:

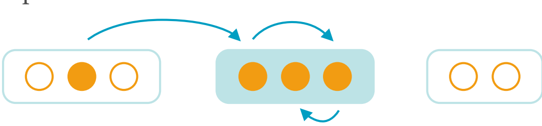
a. **Read the full document** to build a complete picture of how site viability, intervention design, procurement and implementation decisions connect. However, keep in mind that cold chain project design is not always linear – you may need to return to past sections for reconsideration as you advance through the playbook.



b. **Consult a specific chapter** to address an immediate question, such as Chapter 4 for technology options or Chapter 6 for financial assumptions. For these focused inquiries, remember that design aspects are not isolated and will impact other elements of your project.



c. **Move between chapters** as new information reshapes earlier assumptions. A market analysis in Chapter 2 may reveal demand for export-grade product that changes the technology requirements in Chapter 4, which in turn alters the financial projections in Chapter 6, which might then have implications on ownership and governance in (Chapter 5). Most of the chapters, especially in Section 2, are interconnected, and changes in any area can have implications on others.



Every cold chain project is unique: Some begin at a landing site where fish quality is poor and post-harvest losses are high. Others originate from a national policy initiative to strengthen cold chain infrastructure, or from an investor evaluating a specific technology for a target region. The playbook accommodates all these entry points, but the assessments across all chapters remain essential for a viable project design. Those assessments span fisheries science, market analysis, energy engineering, financial modelling, governance design and community engagement. The reader can strengthen every assessment by assembling a project team early, drawing on marine research institutions, energy specialists, financial advisors, local government authorities and community leaders.

To summarize the key questions developers should be considering prior to cold chain investment, we have included a 'Project checklist' on page 7, a resource to help navigate this playbook and guide the process. Further information can be found in the relevant chapters.

VIABILITY OF THE GEOGRAPHIC LOCATION

Before committing resources to a cold chain project, stakeholders must confirm that the proposed site meets three foundational prerequisites. The site must have sufficient and sustainable fish supply, accessible market demand, and reliable energy and water infrastructure. These prerequisites are interdependent, and weakness in any of them will compromise the viability of the entire investment. This section provides the frameworks needed to evaluate each prerequisite rigorously, grounded in the practical realities of SWIO fishery value chains. After completing this section, the reader will be able to determine whether a proposed site can sustain commercially viable cold chain operations. Chapter 1 guides the assessment of fish stock volumes, species composition and seasonal patterns to establish supply-side viability. Chapter 2 examines whether market demand is sufficient to absorb projected output at viable prices. Chapter 3 addresses the availability and reliability of energy and water, which together determine whether cold chain technology can operate consistently and safely at the site.

CHAPTER 1: ASSESSING PRODUCTION CAPACITY & SEASONALITY

Prior to investing in a fishery and/or related cold chain technology, certain critical conditions must be met for a "viable project foundation," the focus of this chapter. In some evaluated fisheries, overfished and declining fish stock levels or seasonality undermine economic viability. This chapter sets the context for assessing the viable project foundation, the most basic level of assessment before committing resources.

Designing an effective cold chain intervention requires a precise understanding of where the existing fishery value chain has challenges. At most target sites, fish is caught, landed and traded through relationships, and channels have been established over many years. Spoilage erodes the value of a catch, inadequate cooling limits access to better-paying buyers, and limited storage prevents fish from reaching the destination market. Mapping those failures across the fishery's actors, infrastructure, handling practices and market linkages is therefore the analytical foundation for every investment decision that follows.

1.1 Produce viability analysis

The very first step is to assess whether there are sufficient, consistent volumes of fish stock to justify investment, which is often termed "produce viability analysis." This involves confirming catch volumes, produce quality, species composition and production cycles, to ensure sustainable continuous operations without promoting unsustainable fishing practices. Further, it provides critical insight into cold chain technology requirements, both type and capacity.

Determine average and seasonal yields of target fish or seafood species. The catch yield data from regional and country-level databases, such as WIOFish that compiles fisheries data from the Western Indian Ocean region, should show consistent supply of fish and seafood landings throughout the year, taking into account seasonal highs and lows.

Action*:* Review regional and/or country-level fisheries databases to obtain catch yield data and understand fish and seafood landings across the peak and low seasons, ideally for several years, which should indicate sufficient volume to justify investment. Additionally, conduct site visits of the landing areas and interview stakeholders to help confirm the data and collect more recent information. Collecting recent data and assessing recent trends is critical as climate change, among other phenomena, is changing habitats, fish stocks and movements.

For more information on production yields and estimates, please refer to FAO's FishStatJ.

Determine quality profile of landed or harvested product. High-quality produce is favourable in both domestic and export markets, to meet food safety standards, hygiene practices, and ultimately attract demand and ensure consistent offtake. Issues on the quality of produce tend to arise due to inadequate storage, handling and temperature exposure at different stages of the value chain; often, up to 20–40% of fish may be lost or downgraded due to lack of proper cooling.[8]

Cold chain infrastructure must address critical vulnerabilities across the entire post-harvest chain, beginning at the point of catch. Effective cold chain outcomes depend on quality handling on board the vessel, including access to good quality ice, insulated storage, and where feasible, onboard

8 Abelti, A., & Abera Teka, T. (2024). Intervening fish post-harvest losses to narrow the gap between demand and supply: A review on magnitude of fish post-harvest losses in some Sub-Saharan African countries. Aquaculture, *Fish and Fisheries*.

refrigeration, all of which directly determine the quality of the landed product and the extent of post-harvest losses. At landing sites and during transport, inadequate thermal control leads to rapid spoilage. Specifically, failing to maintain the thermal threshold of minus 18°C significantly reduces the storage life of frozen products. For example, fatty fish and shrimp lose quality within five months at -18°C, whereas deeper freezing to -30°C can extend their shelf life beyond 12 months.[9] Additionally, storage longevity is highly sensitive to temperature fluctuations, which accelerate spoilage and significantly reduce shelf life.[10] More information on the maximum storage duration for key products at specific freezing thresholds can be found in FAO's Freezing and refrigerated storage in fisheries. Without robust infrastructure, such as high-density insulation and solar-backed monitoring, challenges of product downgrading can easily arise without anyone immediately knowing.[11]

Action: Assess, either through available data or primary research, the quality profile of the produce, the species composition and seasonal volumes. Additionally, confirm the produce is properly handled and stored in temperature-controlled ways; the objectives of any cold chain investment will be to fill current gaps. Price received on the outputs is also a good indicator for how the market is perceiving the quality.

Determine harvest control rules and/or sustainable catch limits and monitoring systems to prevent overfishing. The impact of the introduction of cold chains on fishing activities can be two-sided. On the one hand, cold chain infrastructure could reduce post-harvest fish loss; at any given demand, the less goes to waste, the less needs to be fished. On the other hand, the introduction of cold chain infrastructure could open new markets and provide higher prices, increasing the demand for fish and putting extra pressure on the fish stocks. Prior to investment, community-level fishery management plans should be in place to regulate against fishing beyond sustainable levels. As supply chains get more profitable, there is an increased risk of overfishing.

Action: Engage with marine and fisheries research institutions, such as Kenya Marine & Fisheries Research Institute (KMFRI), Western Indian Ocean Marine Science Association (WIOMSA) and regional fisheries management organizations (RFMOs), which increasingly support data collection, capacity management and co-management for artisanal and small-scale coastal fisheries to understand the realities and sustainability of current fishing practices. Abide by compliance quotas and licensing frameworks to ensure sustainable fishing practices and/or adopt management frameworks, including gear regulations, licenses, quotas and marine spatial plans, to ensure that fishing remains at sustainable levels.[12] Should fish stocks be considered overexploited, it is vital that any investment in cold chains be accompanied by additional fisheries management controls. Many small scale fisheries in the SWIO region are considered data deficient making the assessment of sustainability very difficult. In this case, cold chain investments should be implemented in conjunction with additional data requirements to monitor the status of fish stocks. Ideally, investments in cold chains could incentivize additional data and reporting of fish catches and can serve as a central point for aggregated data collection.

For more information on sustainable fishing, please refer to the Marine Stewardship Council.

9 FAO. (1994). Freezing and refrigerated storage in fisheries.

10 Ibid.

11 FAO. (2025). Solar energy and the cold chain: A guide for small-scale fisheries interventions.

12 ECOFISH. (2022). Assessment of regional/national fisheries management plans and related activities in the SWIO region (Volume 1).

Fish harvest at the Takaungu landing site in Kenya

Table 1: **Factors to consider for the produce viability analysis**

Factor	Description or Rationale	Verification Method
Stable supply volume	Annual production (wild or farmed) is sufficient to sustain regular throughput and consistent utilization of the planned cold chain investment throughout the year	Review of landing-site data, evaluation of fisheries statistics, analysis of farm production data, monitoring and consultations at landing sites
Stable species mix	Identified target species make-up should remain consistent across harvest seasons, avoiding reliance on short-lived or overexploited stocks	Species composition surveys, catch and harvest monitoring
Good baseline quality	Fish arrive at landing sites in high-quality condition through proper handling and temperature control; losses are due to lack of cooling rather than other conditions	Visual inspections and quality grading at landing points
Sustainable fishing or aquaculture	Ensure catch and harvest are conducted within biologically sustainable limits; national fisheries management plans in place	Assessment of stock status; review of landing data, catch limits and quotas, licenses, or aquaculture permits

1.2 Seasonality assessment

Analysing and understanding seasonality within fishery value chains is essential to accurately project volumes, which determine commercial viability. Fisheries within the SWIO region experience distinct high and low production seasons due to weather patterns, ecological cycles, breeding seasons and monsoon conditions.[13] These factors directly impact catch volumes, species availability and market prices, which directly shapes the economics for projects and communities.

Determine fishing seasons and their durations. Avoiding seasonality is impossible, so it is important to analyse records on catch and harvest seasons for better planning, for both financial and operational purposes. Catch planning, based on empirical evidence and trends (especially to capture climate-related changes in patterns), is critical to understand the timing and duration of seasons, and ultimately to project revenues and optimize utilization of the cold chain investment.[14]

***Action**:* Review fisheries databases for the region to understand the peak and low seasons to help inform catch projections (for financial modelling, see Chapter 6), and ultimately cold chain capacities required. Secondary data should ideally be validated through primary research (i.e., observing landing sites, conducting consultations with fishermen, etc.). Critically, historical records and present catch data should be interpreted considering climate change, which is altering fish distribution, shifting seasonal patterns, reducing yields in warming waters, and increasing the frequency of extreme weather events that disrupt fishing operations. Where possible, assess recent trends over multiple years to identify climate-related shifts that may affect the reliability of historical baselines for future planning.

For more information on production cycles, please visit marine fisheries databases such as KMFRI's Digital maps of fisheries of Kenya.

13 ECOFISH. (2024). Brief on potential impacts of climate change on small-scale fisheries in the SWIO region.

14 FAO. (2024). The state of world fisheries and aquaculture.

Evaluate opportunities to balance seasonality across species, production areas, and other products. If possible, different species and or complementary landing sites should be identified to balance utilization and keep it at high levels all year round, even during low seasons for the main produce. Multi-species sourcing can unlock new customers and markets and helps smoothen supply and avoid idle periods.

Action*:* Assess the seasonality of different species and consider filling the remaining capacity. For example, during low seasons for the main species (e.g. prawns), supplement with other species (e.g. demersal fish, like snapper).[15] Beyond the fishery sector, there's also demand for cold chains in dairy, meat, vegetables, healthcare, or even ice flakes in the hospitality industry that can be captured to increase utilization rates. However, storage must ensure strict separation from potential contaminants to maintain biological and sensory integrity in accordance with local legislation.

For more information on species seasonality for a particular region, please review fisheries databases such as WIOFish, *which includes data for Mozambique, Kenya, Seychelles, Madagascar, Comoros, Mauritius, Tanzania and South Africa, among other. For more on seasonality, species mixes and growth cycles, please refer to* FishBase.

15 ECOFISH. (2022). Assessment of regional/national fisheries management plans and related activities in coastal marine fisheries of cluster 1 of the EA, SA and IO region (Volume 2).

Assess how weather conditions affect fishing operations, safety, and catch volumes. Weather variability often determines when fishing activity is highest or lowest and therefore affects the timing and volume of landings. Climate change may alter fish distribution, migration patterns and seasonal productivity. Although precise climate projections remain uncertain, understanding historical weather variability and emerging climate trends is important for both operational and strategic planning. Better understanding these patterns and trends allows maintenance to be scheduled during periods of lower catch, and usage of excess capacity can be planned and utilized more effectively.

Action: Review meteorological data alongside catch data and assess the impact of climatic conditions on the production of fish and seafood, based on empirical data. This empirical analysis should be complemented by a review of relevant climate projections to assess potential long-term changes in ocean conditions, fish distribution and seasonal productivity, so operational planning, infrastructure design and revenue models remain resilient under a range of future environmental scenarios. As discussed, plan for high and low seasons to ensure consistent cashflows, embedding alternative revenue models within the project's strategy, as needed.

Please refer to the Project Viability Checklist in the Tools and Appendices for a practical guide on determining if a fishery cold chain project is viable.

Fisher Yussuf Baya shows his day harvest in the Takaungu landing site, Kenya

© UNITED PICTURES LTD & WWF

Fishers carry their catch back to shore, Tanzania

© BLANCA EIZAGUIRRE / WWF-UNEP

Fishers sort their catch, Tanzania

© EGNO NDUNGURU / WWF-TANZANIA

CHAPTER 2: UNDERSTANDING THE MARKET OPPORTUNITY

After assessing produce viability from the supply side, it is important to determine if the market is sufficiently large to justify investments. This includes understanding how the market operates, how competitive it is, who the key off-takers are in both domestic and export markets, how they source their produce and at what terms. In the SWIO region, lacking market linkages are arguably the biggest challenge for most fishers, often exacerbated by limited cold chain infrastructure, fragmented value chains and traceability issues.

2.1 Market mapping & demand analysis

Identifying the market's key players , including their roles, balance of power, etc. is critical for knowing how and with whom to engage, including suitable off-takers. Furthermore, this will help reveal if and how cold chain investments will increase demand and open up new client segments. For project developers, it's important to fully understand market needs and wants to align efforts with demand, rather than attempting a 'product push'. This includes knowing if the catch volumes can be marketed, and specifically, where and how produce is sold (including domestic versus export markets), quality expectations, buyer preferences, prices and other incentives.

Map out key actors along the fishery value chain and their relationships. Based on the target market, whether domestic or export, it is important to understand who the fishers, aggregators, processors, transporters and retailers are, how they work together (spot trade vs long term off-take agreements) and how products and payments flow. All these stakeholders fulfil different roles in the value chain to ensure produce reaches the consumer. Also, they might have long-standing established relationships, which could impact their willingness or terms to engage with new projects.

Action: Research key stakeholders, including off-takers, and understand their roles, activities, level of influence, and operational activity. If possible, determine who they partner with currently and analyse if the project/product has any competitive advantage or other ways to position the value of cooperation. Map out an overview of all key stakeholders and their roles/relationships and identify opportunities and potential bottlenecks – such as delays in transportation and payments – to be fully prepared when operations begin.

Analyse demand in local markets. Local, smaller buyers typically value freshness and affordability, whereas larger, commercial buyers look for consistent supply volumes, quality and hygiene standards. Compliance to food safety standards is essential, especially to access more formal buyers. Different client segments will also offer different prices, including quality premiums and other sales terms (which often impact working capital requirements for fisheries). Domestic markets can have the same quality expectations as export markets, as we will discuss. However , they will generally be much easier to access and serve.

Action: Identify key local off-takers and their requirements in terms of their preferred species and whether the produce should be fresh, chilled, frozen or even processed. Understand their volume requirements and prices to identify suitable local clients for the project. Also, assess their fit, including their objectives, terms and market reputation, and create a prioritized shortlist of offtake partners. A multi-segment approach is often beneficial for traders operating only locally (e.g., alongside selling to fish wholesalers, also selling directly to hotels, restaurants, etc.), as one segment alone might not require enough volume and to reduce risk through diversification.

Fish evaluated before market, Tanzania

© EGNO NDUNGURU / WWF-TANZANIA

Fish auctioned at market, Tanzania

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Analyse demand in export/regional markets. Export markets typically target high-value species and tend to focus more on traceability, certification, food safety compliance and high-quality temperature-controlled produce from harvest to delivery. Export markets can offer interesting opportunities to increase volumes and/or prices, ensure consistent offtake, and geographically diversify demand. Note that developing export chains can have negative impact on the availability of fish for the local market and nutrition security.

Action: Evaluate the compliance requirements and other (regulatory or competitive) barriers for target export markets to identify feasibility and operational needs. Consider the total costs from catch all the way to end delivery to help understand the economics, identify bottlenecks and set up corresponding mitigation strategies. Export markets can have the same quality expectations as domestic markets, but transport logistics, standards and regulations will often differ significantly, and serving them often leads to increased complexity. Financial modelling helps to assess the attractiveness of targeting either local or export markets or taking a hybrid approach.

Analyse which off-takers are reliable and capable of sustaining consistent demand. Buyers with established market outlets, creditworthiness, formal contracts and purchase histories should provide a reliable and stable market for the produce. Developers should also assess the availability of cold chain technology across potential off-takers, particularly in remote or off-grid settings, as the absence of cooling capacity at the buyer level will constrain effective demand. Where gaps exist, developers may need to facilitate access to cooling technology for key off-takers to secure consistent volumes. These types of buyers might not always be easily accessible in the SWIO region, making it important for developers to have "ears on the ground" to learn from the locals about the performance and reliability of different off-taker channels.

Action: Assess the different off-takers, taking into consideration their demand and preferences. Research their volumes over the years to ensure there is strong consistency and growth. Identifying the right buyer(s) will be based on the project's target market and capacity to meet their demand. Only commit to formal contracts once you know that you will be able to deliver to the requirements (i.e., you have sufficient clarity on the project and timelines). Note that formal contracts are less common in fisheries in the SWIO region and mostly only effective for larger developments and volumes.

For more information on fish trade and consumption data, please refer to FAO's FishStatJ.

Fishers Charo Mwaro (right) and Yussuf Baya arriving at the Takaungu fish land site

2.2 Other critical intelligence

Investing in fishery operations further requires deeper understanding of food safety and handling requirements, which, alongside market demand will determine in what state the fish is sold (e.g., fresh vs. frozen).

Determine the quality, traceability and packaging requirements. Understanding quality, traceability, hygiene and packaging requirements is foundational for any cold chain project that aims to supply to more formal or export markets. The level of effort required will vary depending on the intended market and buyer requirements. Cold chain infrastructure will only be able to deliver value if products can legally and commercially access the target markets. For instance, the European Union requires:[16,17]

- Strict temperature control (critical given the ambient temperatures in the SWIO region)
- Sanitary handling and processing practices
- Approved facilities and equipment
- Traceability from capture of fish to sale
- Export health certificates

To meet these requirements stringent processes and standards need to be in place (e.g., around temperature thresholds, labelling, and certification), to ensure the products meet export market requirements.

16 European Commission. (2018). EU import conditions for seafood and other fishery products.

17 FAO. (2005). Causes of detentions and rejections in the international fish trade.

Action: Review industry standards and regulations of the target markets, with a focus on quality, traceability, labelling and certifications. Develop a clear understanding of these requirements ahead of any negotiations with off-takers. Be sure to embed all the standards required and how to meet them into the operating model.

For more information on what to consider for when accessing formal markets, refer to FAO's Causes of detentions and rejections in international fish trade.

Assess price differences between fresh, chilled and frozen products. Fresh, chilled and frozen produce will attract different prices in different markets, so it is important to verify client segments' needs and wants, operational realities of logistics, and then to identify the project's target product.

Action: First, understand what the key off-takers want, and whether the project's location and logistics infrastructure has implications on the choice of type of product. Then, subject to that, conduct a pricing assessment on fresh, chilled or frozen produce of the target market and determine premiums set for high-quality produce. This will help determine what types of products to prioritize.

Define logistical routes and market infrastructure. Effective distribution requires adequate infrastructure at every point in the chain, from landing site to end market. At the landing site, cooling facilities such as ice plants, chilled storage and pre-cooling systems must be in place to preserve produce quality before transport begins. Along distribution routes, transport infrastructure including refrigerated trucks, ports and airports must support timely delivery without compromising quality or price premiums. In the SWIO region, coastal infrastructure including ports, landing sites and roads is increasingly exposed to sea level rise and extreme weather. Route planning must account for these climate risks to ensure reliable year-round distribution.

***Action**:* Work closely with established off-taker connections and understand their ideal sourcing model for the product at hand; for instance, understanding cooling requirements for frozen vs. fresh fish and the distance to the end buyer. Then, based on the buyer's specifications, more informed investment decisions can be made, like whether refrigerated trucks or reliable cooling storage in non-refrigerated trucks make the most economic sense. In short, the goal is to keep each fish cooled all the way from catch to consumption by the end consumer, focusing primarily on areas within control.

Table 2: Key value chain aspects for consideration

Aspect	Description or Rationale	Verification Method
Map the fishery value chain end-to-end	Understand the stakeholders, their roles, market dynamics, and existing relationships / networks. Identify opportunities and potential bottlenecks and ways to overcome them	Rapid market assessments to map out key players and understand their roles; often this involves conducting stakeholder consultations
Identify reliable off-takers and their preferences	Finding the right off-taker can make all the difference, especially for community-level fishery projects. Off-takers vary significantly, not only by volume and price, but also by reliability, mission alignment, terms, and other factors.	Shortlist prioritized off-takers and conduct "due diligence", (e.g., have in-depth conversations on their business, complemented with referrals and market consultations).
Compliance with market standards	Industry standards and regulation (e.g., the facility design needs to meet required temperature, hygiene and certification norms)	Adopt industry standards and regulations and obtain required certifications
Price premium for high-quality produce	Often some differentiation can make a lot of difference to margins and overall profitability. Assess which product or branding strategies can support that (e.g., is there a measurable price/margin difference for frozen vs. fresh fish?)	Price analysis across all fishery products, including fresh, chilled and frozen produce, and competitive research to understand how brand positioning impacts pricing
Reliable distribution network	Effective cold chain logistics from landing to market to maintain quality of the produce	Assessment of logistical routes and transportation mechanisms; map out the processes within the project's control (i.e., What processes and infrastructure are needed to ensure high-quality produce is delivered to the off-takers?)

CHAPTER 3: UNDERSTANDING THE AVAILABILITY OF ENERGY AND WATER

Energy and water are key utilities that ensure the performance, safety and durability of cold chain technologies[18] and hygienic handling in the value chain. It is therefore important to confirm access to reliable energy and good quality water source(s).

Energy and water assessment and cold chain technology selection are interdependent processes. The assessments in this section connect directly to decisions in other chapters, particularly Chapter 4: Selecting the right cold chain technology, and should be revisited as those decisions evolve. Developers should first evaluate the availability of energy and water to inform and potentially narrow technology options. Once a preferred technology has been identified, developers should confirm full compatibility between the cooling unit and available energy and water sources.

3.1 Energy source selection

Energy choices determine operating costs, equipment uptime, reliability and environmental impact. Reliable energy ensures the facility can produce ice consistently, maintain cooling temperatures and avoid spoilage. In coastal and remote communities, grid reliability varies significantly, making it essential to evaluate alternatives, such as solar photovoltaics (PV), battery storage, phase-change materials or backup generators.[19] Selecting the right mix reduces downtime, ensures food safety and supports commercial viability.

Kenneth Nyambu (right) lead technician at the Takaungu Solar Ice plant trains attendant Said Mkali on the machine operations manual

18 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

19 Lopez, W., Sepúlveda, H., & Mattar, C. (2021). Off-grid hybrid electrical generation systems in remote communities: Trends and characteristics in sustainability solutions. *Sustainability*.

Define the reliability and availability of the primary energy source. The energy source is a key criterion in the location decision (e.g., off-grid vs. on-grid), and whether on-grid, off-grid or hybrid, should deliver consistent uptime and voltage stability to support refrigeration loads and prevent equipment damages. Ideal conditions include minimal outages, predictable tariffs and the ability to meet peak power demand (**Table 3**). Sites with reliable grid access generally have significantly lower initial capital expenditure and long-term operational costs without the need for expensive diesel generators or battery storage systems. Hybrid systems, offering a backup option to either the grid or solar system, are often beneficial to ensure operational continuity. The energy source should also consider the cold chain technology selected, ensuring compatibility.[20]

***Action**:* First, assess what energy source could be accessed on site and its current condition. For grid-based systems, map the physical connection points, including the distance to the grid, transformer condition and wiring quality. In addition, determine whether the connection is single-phase or three-phase and confirm the voltage level. For solar-based systems, assess potential locations for installing solar panels, such as rooftops or available ground space. Second, evaluate the stability and reliability of the energy source. For grid-based systems, monitor the frequency and duration of power outages, voltage fluctuations and surges, seasonal variability, and total downtime per week. For solar systems, obtain local climate data to assess average daily sun hours and seasonal variation.

For more information on energy needs, specifically for cold rooms as an example, please see Walk-in cold rooms, a practitioner's technical guide by Efficiency for Access.

20 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Table 3: Critical conditions for the energy source

Condition	Description or Rationale	Verification Method
Reliable energy source	Ability of the chosen source to deliver stable and continuous power for cooling operations	Interview site users on daily outage hours and when issues such as "dimming" lights are experienced
Adequate capacity	Energy infrastructure sized correctly for start-up load, peak load and operational cycles of the cold chain	Load calculations, equipment specifications from supplier
Cost transparency	Clear visibility on initial capital expenditure (CAPEX), tariffs, fuel costs, maintenance and other operating expenses (OPEX)	Review quotes, utility tariffs, service contracts, etc.
Backup or redundancy	Presence of alternative power source (battery, generator, phase change materials) for critical operations	On-site inspection to confirm backup systems (batteries, backup generators, or phase-change materials such as thermal lining); review CAPEX budget for associated costs
Available technical support	Access to technicians for servicing, troubleshooting and repairs	Verify supplier has a local technician and phone number that works

Assess if the energy infrastructure can support the total load and duty cycle of the cold chain needs. The energy source should be based on accurate load assessments as per market demand. For instance, the expected fish volume, number of storage cycles and storage temperature will determine the required capacity of the cold chain technology. which determines the energy load.[21]

21 FAO. (1994). Freezing and refrigerated storage in fisheries.

Action: To assess the compatibility between the energy source and the intended cold chain technology, a simple assessment can be conducted in three steps:

1. **Identify the basic energy requirements of the cold chain technology.** This includes the type of cold chain technology, its rated power (from the supplier brochure, in kW), the expected hours of operation per day and whether continuous power is required.
2. **Then, compare the requirements with the realities.** Assess how many hours per day there is reliable power, the typical length of outages and whether any backup power source exists to verify energy source compatibility. In areas with weak grid reliability, consider the need for hybrid systems to ensure continuous cold chain operations, noting that these solutions will increase overall system costs. Ensure that the energy source has appropriate wiring, adequate transformer capacity (for grid-connected systems) and the ability to accommodate future load increases as production volumes grow. For off-grid systems, battery sizing should be able to support night-time and cloudy conditions (potentially combined with thermal batteries). If cost is not prohibitive, batteries should be sized to guarantee a few days of autonomy, ensuring operations continue during cloudy weather or power outages.[22]
3. **Lastly, verify technical compatibility between the energy source and the cold chain technology.** Confirm whether the equipment requires single-phase or three-phase power, the voltage level, and whether a stabilizer or inverter is needed. Most commercial on-grid cold chain technologies require three-phase power to efficiently operate. Also determine whether the system operates on direct current (DC) or alternating current (AC). For example, solar panels produce DC power, while most cold chain equipment operates on AC power; therefore, solar-based systems require an inverter to convert DC to AC.[23] When sizing an inverter for compressor-based cooling technology, the inverter must be rated to handle the compressor's surge power demand during start-up, which significantly exceeds normal operating load. Undersized inverters are a common cause of system tripping in solar-powered cold chain installations, and developers should account for this requirement early in the project design.

Determine the costs of the selected energy system.

Developers must understand the full cost of operating the energy system and confirm that these costs are financially sustainable over the long term. This requires estimating energy consumption costs, planning for regular maintenance and servicing, and testing total costs against projected income.[24] Trade-offs are common – for example, solar-battery systems reduce operating costs but require higher upfront investment.[25]

Action: Conduct a simple energy cost analysis in four steps. First, estimate daily energy consumption by multiplying the rated power of the equipment (in kW) by average daily operating hours (for example, a 5 kW cold room operating 12 hours per day consumes 60 kWh per day). Second, identify the unit energy cost by source. For grid electricity, use the tariff per kWh. For solar, estimate the levelized cost by accounting for system lifespan and investment costs. Third, calculate monthly energy costs by multiplying estimated monthly consumption (kWh/month) by the unit cost per kWh, and add operating and maintenance costs such as solar system maintenance, battery replacement and inverter servicing. Fourth, compare total energy costs against projected

22 Lopez, W., Sepúlveda, H., & Mattar, C. (2021). Off-grid hybrid electrical generation systems in remote communities: Trends and characteristics in sustainability solutions. *Sustainability*.

23 UNICEF. (2014). Battery powered solar refrigerators and freezers.

24 FAO. (1994). Freezing and refrigerated storage in fisheries.

25 World Bank. (2022). Practical guide on sustainable cold chain.

business income to assess affordability (see Chapter 6 for detailed financial viability analysis). Developers should also secure service contracts for the energy configuration with clear service level agreements, and plan these costs upfront.

3.2 Water supply management

Water is a critical input for ice machines, cleaning processes and some cooling systems. Poor water availability or quality increases operational costs, reduces equipment lifespan and creates food safety risks. Many coastal or island communities face challenges such as high salinity, turbidity, unstable supply or seasonal shortages, making water assessment a fundamental part of project due diligence.

Assess if there are adequate and reliable water sources to meet daily operational needs. This includes ensuring consistency and volumes throughout peak and low seasons. For instance, the amount of water needed to make ice is equal to the amount of ice produced plus a buffer for wastage and prevention of build-up of solids in the water circulation system.[26] Freshwater is scarce in many SWIO countries, so it is vital to evaluate how shifting rainfall patterns or prolonged drought might impact water availability over the project's lifespan. Local government priorities can change in times of scarcity – for example, water is often diverted to drinking supplies or agriculture, which may leave cold chain operations at risk. To overcome some of these potential risks, operators increasingly use ice seawater slurry systems or seawater-compatible ice machines.[27] These systems can be viable alternatives if the water quality meets the hygiene requirements of the intended market (e.g., seawater ice may be acceptable for preserving whole fish destined for local markets, but not always for export-grade products).[28]

***Action**:* Conduct a full water supply assessment to confirm that daily and seasonal water volumes can reliably meet the cold chain's operational needs (**Table 4**). Verify flow rates, daily replenishment capacity and seasonal variability and map potential disruptions, such as drought periods that could affect the water supply. The assessment should also account for climate change risks that may affect long-term water reliability, including shifting rainfall patterns and changing coastal conditions. Ensure that all volume estimates are tied directly to the capacity and duty cycle of the selected technology (e.g., litres required per tonne of ice) to avoid operational bottlenecks.

Evaluate if the water quality meets standards for food-safe ice production and equipment protection. The quality of the water used for ice production, water cooling systems, cleaning processes and/or any direct contact with the produce should be tested to confirm that it meets water safety and hygiene standards. As mentioned above, high salinity, turbidity, microbial content and mineral deposits damage equipment and produce unsafe ice.[29] In facilities that use water-cooled condensers common in tropical, high-humidity environments water quality is also critical as poor water quality accelerates fouling, scaling and corrosion inside the condenser, reducing efficiency and shortening equipment lifespan.[30] Selecting an appropriate treatment system therefore ensures both food safety and reliable technology performance, particularly in coastal SWIO areas where brackish groundwater is common.[31] Please see **Table 5** for water issues that impact equipment and ice quality and the appropriate treatment solutions for the water issues.

26 FAO. (2001). Icemaking plant.
27 FAO. (2003). The use of ice on small fishing vessels.
28 FAO. (2009). Code of practice for fish and fishery products.

29 FAO. (2023). Safety and quality of water used in the production and processing of fish and fishery products.
30 CRFM. (2016). Manual on assuring food safety conditions in fish landing and processing.
31 Idowu, T.E., & K.H. Lasisi. (2020). Seawater intrusion in the coastal aquifers of East and Horn of Africa: A review from a regional perspective. *Groundwater for Sustainable Development.*

Table 4: Critical conditions to consider when establishing water supply

Condition	Description or Rationale	Verification Method
Adequate daily volume	Sufficient water for ice production and cleaning needs	Site assessment, supplier confirmations
Food-safe quality	Water free from contaminants to ensure hygiene and equipment protection	Quality testing reports (salinity, total dissolved solids, microbial tests)
Cost efficiency	Affordable and predictable water pricing for sustainable operations	Supplier contracts, cost modelling
Treatment requirements	Alignment between water quality and chosen purification method	Review test results and treatment system specs
Source reliability	Water availability throughout the year, including dry seasons	Historical supply data, community interviews

Table 5: Overview of water issues, with impact and treatment solutions[32]

Water issues	Impact on equipment and ice quality	Appropriate treatment solutions
Microbial contamination	Unsafe ice, biofilm inside piping, fouling in water-cooled condensers	UV treatment, chlorination, ozonation
High salinity or brackish water	Corrosion of pipes and coils, unsafe for ice, condenser rusting	Reverse osmosis
High Total dissolved solids	Scaling on condenser plates, reduced cooling efficiency, unsafe ice	Reverse osmosis
Turbidity or suspended particles	Clogging of nozzles and filters, fouling of condenser water circuits	Sand filtration, cartridge filtration
Hardness (calcium, magnesium)	Heavy scaling on evaporators and water-cooled condensers, reduced efficiency	Water softeners, anti-scale material of the equipment
Organic matter or colour	Odour, biofilm formation, poor ice quality	Activated carbon filtration

32 FAO. (2023). Safety and quality of water used in the production and processing of fish and fishery products.

Fishers bring a large fish to shore, Tanzania

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***Action**:* Conduct a baseline water assessment prior to making any technology investment decisions to ensure the water source meets requirements and is reliable. This includes water testing (salinity, total dissolved solids, microbial presence) and the assessment of the need for water treatment systems and purification methods such as filtration, UV treatment, or reverse osmosis.[33] Water tests should be conducted on a quarterly basis to monitor any changes.

For more information on water safety and quality, please see FAO's Safety and quality of water used in the production and processing of fish and fishery products.

Assess wastewater discharge requirements and environmental compliance. Cold chain operations generate wastewater from ice production, equipment cleaning, and processing activities. If not properly managed, untreated wastewater discharge will contaminate coastal and marine environments and create regulatory risk. Compliance requirements will influence site selection, infrastructure design and operating costs, and developers should identify applicable local and national discharge regulations early.

Action: Identify the wastewater streams the cold chain operation will generate and assess the volume and composition of discharge. Determine applicable local and national regulations governing wastewater discharge, particularly in coastal and marine-protected areas. Where treatment is required, evaluate appropriate solutions and include associated infrastructure and operating costs in the project's financial projections (see Chapter 6 on financial viability).

33 FAO. (2012). Fishery Products Hygiene Regulations.

Calculate that the cost of water supply is financially sustainable for long-term operations. Water costs are a key consideration in assessing the economic feasibility of the operations, and the investment needs to be aligned to the economic potential of the project. In budgeting, all costs need to be considered from sourcing and treating to maintaining water systems, including tariffs, pumping costs, trucked water pricing and treatment OPEX such as filters, membranes, chemicals and routine testing.[34]

***Action**:* Assess all water-related costs of the project, including sourcing, treatment, water supply facilities where needed and maintenance costs, including spare parts for water systems. Obtain agreements from water suppliers and maintenance service providers to ascertain costs and lead times as well as to support budgeting efforts. Include all upfront and ongoing costs in the financial projections and recurring budgets.

34 FAO. (2023). Safety and quality of water used in the production and processing of fish and fishery products.

Walter Kalama, fisher and Viice Chair of Takaungu BMU sorts his harvest at the Takaungu landing site, Kenya

Tima Ali, Fish dealer in Kiwayu Lamu checking on her fish in the coolers

INTERVENTION DESIGN

Once stakeholders have confirmed site viability, the developer must make three interdependent decisions that will determine whether the project succeeds. First, the cold chain technology must match the fish volumes, quality requirements and infrastructure conditions of the site. Second, the ownership and governance structure must align stakeholder incentives, ensure accountability and fit the institutional realities of the local context. Finally, the financial model must demonstrate that the project generates sufficient revenues to cover its costs and sustain operations over time. After completing this section, the reader will be able to design a cold chain intervention that is technically appropriate, institutionally sound and financially viable. Chapter 4 guides cold chain technology selection and capacity sizing. Chapter 5 addresses ownership, governance and operating model selection. Chapter 6 provides the tools to assess financial viability and construct a business case capable of attracting and sustaining investment.

CHAPTER 4: SELECTING THE RIGHT COLD CHAIN TECHNOLOGY

Once the geographic location's viability has been determined, the next step is to choose the right cold chain technology. This chapter will provide technical guidance to understand the various cold chain technologies available and how to assess their suitability for the project needs. Please note that the selection of the appropriate cold chain technology is closely linked to the size of the project (e.g., an ice maker is often sufficient for small volumes, vs. industrial cold rooms for large volumes), as well as availability of energy and water sources, institutional capacities, and existing policies and governance frameworks. Effective cold chain development also requires complementary interventions, including improved food safety and handling practices, to ensure that infrastructure investments deliver their intended outcomes.

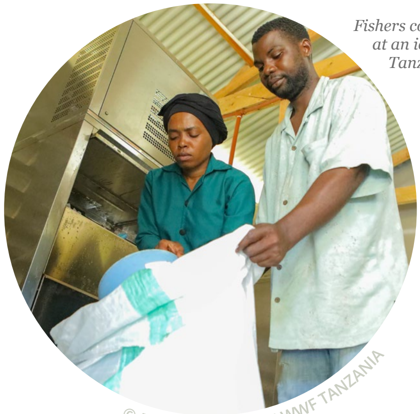
4.1 Overview of cold chain technologies

The Southwest Indian Ocean (SWIO) region has unique operating conditions due to high temperatures, humidity, salinity and unreliable grid power, which can impact cooling efficiency and equipment lifespan. Poor technology selection at the onset of a fishery cold chain project is one of the leading causes of operational failures, leading to stranded assets.[35] Also, it is important to consider the climate impact of cold chain technologies, which is discussed more in Chapter 8. This section will provide:

- An overview of cold chain technologies applicable to fishery value chains; and
- Guidance on how to select the right cold chain technology based on the project's needs.

Cold chain technologies utilized commercially in fishery value chains are mostly grouped into three categories: 1) ice production equipment, 2) freezing systems, and 3) cold room solutions. Each of these technology categories serves a different purpose, ranging from cooling on the vessel and rapid chilling at catch landing sites to refrigeration and deep freezing. In addition, cooling systems for transportation (e.g., within lorries), can form a fourth category relevant to logistics providers. Identifying the preferred technology from these categories requires an understanding of their characteristics, capabilities, operating requirements and suitable use cases.

Ice-based cooling systems: Ice is widely used as a cooling medium for fishery value chains across the SWIO region due to its ease of access and transportation, and ability to rapidly cool freshly caught fish. Different ice types offer different cooling properties and are suited to specific species and contexts. For example, flake ice provides excellent surface contact for high-value species, slurry ice offers rapid chilling ideal for small pelagic fish, while block ice is suitable for remote areas requiring slow-melt transport. Table 6 summarises common ice-based cooling systems and their key features.



Fishers collect ice at an ice plant, Tanzania

© EGNO NDUNGURU WWF TANZANIA

Catch on ice, Tanzania

© ZEPHANIA ARNOLD / WWF TANZANIA

35 WWF. (2023). Scaling up cold-chain solutions in the Southwest Indian Ocean.

Table 6: Overview of ice-based cooling systems[36]

Technology	Key considerations	Typical output & Energy Needs	Species fit	Market player category
Flake ice machine	*Used for pre-cooling, chilling, short-term storage* *Pros:* Excellent surface cooling; ideal for sensitive/ high-value species *Cons:* Requires clean water and consistent maintenance; higher CAPEX	0.5–10 t/day; 70–80 kWh/t	Tuna, octopus, shrimp, premium reef fish, fillets	Medium-high maturity sites, processing plants, large vessels
Tube ice machine	*Used for pre-cooling, chilling, short-term storage* *Pros:* Durable; slow melting; good for transport *Cons*: Less efficient for direct chilling, higher energy use; heavy ice format	1–20 t/day; 80–90 kWh/t	Mixed-species bulk, products in rigid containers	Wholesale ice suppliers, distributors, logistics companies
Block ice machine	*Used for pre-cooling, chilling, short-term storage* *Pros*: Low CAPEX; slowest melt rate; useful in remote transport *Cons*: Requires crushing; hygiene depends on handling practices	1–20 t/day; 30–40 kWh/t	Robust species (for bulk), products in long-distance transit	Remote BMUs, low maturity markets, long-distance transport hubs
Water ice slurry machine	*Used for pre-cooling, chilling, short-term storage* *Pros*: Fastest cooling; ideal for pelagics *Cons*: High heat transfer; corrosion risk; requires pumps/filters; operator training needed	1–10 t/day; 60–70 kWh/t	Small Pelagics (Sardines, Mackerel), Tuna (immediate chilling)	Tuna fleets, large pelagic processors, on-board freezers
Ice packs **(to be used in insulated boxes)**	*Used for short-term storage* *Pros*: Low-tech; mobile; good for micro-operators *Cons:* Cannot support large volume. Food safety concerns when not cleaned between uses.	N/A	High-value, small-batch species, retail display	Micro-fishers, bridging transport gaps, retail markets

36 FAO. (2001). Icemaking plant.

Freezing systems: Freezing technologies are used for pre-cooling to rapidly reduce the temperature of the fish when fish needs to be preserved and stored in the medium- to long-term. They may also help meet export-grade quality requirements as well as to manage seasonal fluctuations in supply. Different freezer types achieve cooling at different speeds and depths. For instance, blast freezers are often used for high-value products such as tuna, while plate freezers are ideal for fillets and blocks. The choice of freezer depends on intended use (pre-cooling vs. frozen storage), product type, required freezing rate, operator capacity and power availability. **Table 7** provides a detailed comparison of freezing technologies most used for smaller-scale operations.

Cold room & refrigerated storage: Cold rooms and chest freezers provide short- or long-term storage for chilled or frozen products, typically at aggregation points, distribution hubs and processing facilities. Subject to catch volumes, available footprints and on-site resources, the developer will determine whether a chest freezer solution or a walk-in cold room fits the operation. Energy supply shapes the configuration thereafter, though most solutions operate on-grid, off-grid or in hybrid arrangements. Chest freezers suit small-bodied fish and low-volume frozen storage at single sites, while walk-in cold rooms serve larger volumes and multi-user aggregation points.

Table 7: Overview of freezing technologies

Technology	Key considerations	Typical output & Energy Needs	Species fit	Market player category
Blast freezer[37]	*Used for pre-cooling and frozen storage* *Pros*: Rapid freezing; preserves texture/quality *Cons*: High CAPEX and energy; requires strong operator capacity	0.25–0.45 kWh/kg	Irregularly shaped products, whole fish, large volumes (e.g., whole tuna)	Export-focused processors, large vessels
Plate freezer[38]	*Used for pre-cooling and frozen storage* *Pros:* Very fast freezing; excellent for fillets *Cons:* Higher maintenance; skilled operators needed	0.20–0.35 kWh/kg	Fillets, packaged products, uniform blocks (e.g., surimi)	Fillet processors, high-value species exporters (structured product)
Brine freezer[39]	*Used for pre-cooling and frozen storage* *Pros:* Fast freezing; ideal for whole fish *Cons*: Corrosion risk; requires salt & monitoring	15–20 kWh/cycle	Whole pelagic fish (Mackerel, Sardines), Shrimp	Semi-industrial processors, vessels targeting pelagics

37 FAO. (1994). Freezing and refrigerated storage in fisheries.
38 Ibid.
39 Mensah, M.E. (2013). Freezing and frozen storage of fish and fish products: A review. North Carolina State University.

Ornate spiny lobster (Panulirus ornatus)

Chest freezers cover a wide range of configurations, and further research should inform any final specification. For fisheries in the SWIO region, two options dominate. The industrial chest freezer serves grid-connected sites, and the off-grid solar direct-drive chest freezer serves sites without reliable grid access. Both are used for frozen storage only and do not meet the timing requirements for pre-cooling under food safety standards. **Table 8** outlines these two options and their optimal applications.

Walk-in cold rooms fall into five main configurations as classified in the Walk-in Cold Rooms Practitioner's Technical Guide.[42] Each configuration operates on-grid, solar PV, diesel or hybrid power, and most accommodate thermal energy storage (phase-change materials or ice banks) or battery backup to bridge outages. For larger footprints, the required solar investment scales substantially and becomes a significant portion of total capital expenditure (CAPEX). **Table 9** outlines the main walk-in cold room configurations and their optimal applications.

42 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Table 8: Overview of chest freezer technologies

Technology	Key considerations	Typical output & Energy Needs	Species fit	Market player category
Industrial chest freezer[40]	*Only used for frozen storage* *Pros*: Affordable; widely available and affordable *Cons*: Slow freezing; not ideal for continuous loading	0.12–0.18 kWh/kg	Small-bodied fish, general low-volume storage	Small BMUs, micro-processors with stable, low-volume loads
Off-grid chest freezer (Solar direct-drive freezer) (SDD)[41]	*Only used for frozen storage* *Pros*: Off-grid; stable performance *Cons*: Limited capacity; slower pull-down; requires good solar resource	5–9 kWp per 100–200 L	Small-bodied, high-value fish (where grid is absent)	Off-grid landing sites, small processors

40 CLASP. (2020). Standards and labeling policy for deep freezers.
41 UNICEF. (2020). Procurement guidelines for solar direct drive refrigerators and freezers.

Table 9: Overview of walk-in cold room configurations

Technology	Key considerations	Typical output & Energy Needs	Species fit	Market player category
Pre-assembled cold room	*Factory-built unit delivered ready for use* *Pros*: Minimal site work; fast installation *Cons*: Fixed dimensions; higher unit cost	20 ft or 40 ft equivalent; grid, solar PV, or hybrid	All product types (chilled or frozen)	Remote sites, off-grid islands, cooperatives
Prefabricated ('flat-packed') cold room kit	*Insulated panel kit assembled on site* *Pros*: Flexible sizing; scalable; container shippable *Cons*: Trained installer required; longer build time	Variable (custom-sized); grid, solar PV, or hybrid	All product types (chilled or frozen)	Processor hubs, aggregation points, project installations
Refrigerated ISO container (Reefer)	*Transport reefer adapted for stationary storage* *Pros*: Robust and reliable; relocatable *Cons*: Heavy doors; unsuited to high humidity; T-bar floor fragile	20 ft (33.2 m³); grid, diesel, or solar retrofit	All product types (chilled or frozen)	Pilot projects, temporary sites, mobile operations
Self-built cold room	*Built on site with local materials and standard refrigeration* *Pros*: Low CAPEX; builds local capacity *Cons*: Variable performance; limited scale	Small scale (<30 m³); grid or solar PV	Chilled product; short-term holding	Community cooperatives, BMUs, training institutions
Converted shipping container cold room	*Dry ISO container insulated and fitted with refrigeration* *Pros*: Modular; widely available; lower cost than reefer *Cons*: Significant conversion effort; door safety must be re-engineered	20 ft (33.1 m³) or 40 ft (67.6 m³); grid, solar PV, or hybrid	All product types (chilled or frozen)	Starter installations, cooperatives, landing site upgrades

For more information on technologies and their components, please see the World Bank's Practical guide on sustainable cold chain and Walk-in cold rooms, a practitioner's technical guide by Efficiency for Access (Paragraph 3.4).

Please note that different cold chain systems use different refrigerants, and both the refrigerant charge and global warming potential (GWP) vary significantly depending on system size and design. In light of national regulations on phase down of refrigerants (see more on page 34), these parameters should be verified as part of the technology selection process.

When selecting refrigerants, developers should prioritize options with low GWP. For smaller systems such as ice makers and display cases, R-290 (propane, GWP ~3) and R-600a (isobutane, GWP ~3) are widely available low-GWP options. For larger industrial cold rooms, R-717 (ammonia, GWP = 0) and R-744 (CO_2, GWP = 1) offer strong environmental performance, though they require additional safety and technical considerations during installation and operation.[43]

43 Forster, P., et al. (2021). "The Earth's energy budget, climate feedback and climate sensitivity." Climate Change 2021: The Physical Science Basis. *Cambridge University Press.*

4.2 Translating market demand to technical capacity

Appropriately identifying the right cold chain technology with the ideal capacity and size will require translating actual target market demand (taking into account sufficient supply) into specifications to support technology selection.[44] Oversizing leads to projects that are not optimally utilized and costly to procure, while undersizing risks leading to bottlenecks, product loss and decline in quality.[45]

Translate market demand into functional requirements and technical specifications. Evaluating expected (target) throughput volumes and converting it to technical specifications will enable effective selection of the cold chain technology based on project needs, to ensure optimal utilization.

Action: Follow the steps on this page to turn what the market needs (volume, quality, timing and price) into what the system must technically deliver (capacity, temperature, power, layout and equipment).

Table 10 summarizes the critical conditions to ensure target throughput is matched to cold chain technology capacity.

Steps	*Illustrative case*
Step 1 – Define the market use case: Consider users, product species and type (fresh, chilled or frozen), storage duration, off-taker requirements, location, available infrastructure and available resources. This step will be informed by assessments done in Chapter 2.	*An operator obtains a contract to supply 1,000 kg of frozen tuna per week to an off-taker in the city, and they require rapid freezing and frozen storage. Any additional tuna catch is sold sporadically to local fish retailers.*
Step 2 – Quantify throughput volumes and capacity/ size requirements: Based on supply and demand analyses, considering seasonality, calculate average and peak daily volumes. Then, under consideration of average and maximum number of storage days, assess cooling capacity and size requirements. In doing so, consider the density of the product, packaging, circulation space and loading/unloading area. For operations relying on ice as the primary cooling method, ice production capacity must be determined using an ice-to-fish ratio calibrated to species type, ambient temperature and handling duration.	*The community operates two wooden, sailing boats for tuna fishing. They make five fishing tours per week, with an average catch of 100 kg per boat per tour, which can increase to 130 kg in peak season. To account for peak season, and for potential future growth, a 1.5x capacity buffer is applied to the average catch. Therefore, total storage capacity for 1,500 kg of tuna is required (2 x 5 x 1.5 x 100 kg). It is common to then apply a "storage density factor" (for packaging and airflow) to the overall catch volume; the density factor depends on how the fish is processed and packed. As a result, the freezer requires a storage capacity of ~2.35 m^3. In addition, if the fish (200 kg per day) is meant to be frozen within say 6 hours, the rapid freezing capacity would need to match that (e.g., 100 kg per 3-hour window).*
Step 3 – Define temperature and performance requirements: Based on product and off-taker requirements, assess suitable technology options; considerations include temperature, temperature stability, humidity and cooling speed (e.g., pre-cooling vs. long-term storage).	*Tuna is a high-value species sensitive to texture loss, and the off-taker requires immediate cooling on the boats, and rapid freezing within hours at the landing site to maintain highest quality.*
Step 4 – Shortlist cold chain technology options: Based on the conclusions drawn from steps 1-3 above, prioritize feasible technology options and document the required technical capabilities and specifications. This assessment should account for energy and water access, operator capabilities, maintenance services availability, relevant environmental factors such as refrigerant type and energy source, and applicable governance requirements including permits, food safety regulations and compliance obligations.	*The warehouse at the landing site is connected to the grid, and has a generator as backup option; further, the water source is reliable and safe. Standard chest freezers cool the fish too slowly, causing cell damage. Therefore, the decision is made that the existing ice slurry should be used to cool the catch on the boats, and after the initial chilling a blast freezer is needed in the warehouse. The blast freezer is to be used for both pre-cooling and storage. Given the proximity to a large city, two technology suppliers are available, and both offer after-sales maintenance services and trainings for the operating teams.*
Step 5 – Determine energy requirements to power cold chain technology: Based on the prioritized cold chain technology, determine the cooling load (kW), daily energy consumption (kWh/day), power source and potential backup needs (see also Chapter 3 on energy source selection).[46]	*The supplier's technical specifications for the blast freezer will provide the required information to assess overall energy needs. In this case, the warehouse is on-grid with a generator as backup solution.*

44 FAO. (2025). Solar energy and the cold chain: A guide for small-scale fisheries interventions.

45 Linble. (2025). Energy-efficient freezer cold room design: Reducing power consumption without sacrificing performance.

46 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Table 10: Critical conditions to translate market demand into technical capacity

Condition	Description or Rationale	Verification Method
Correct freezing rate	Freezers must achieve the kg/h needed to freeze peak daily loads within required timeframes; slow freezing reduces quality and market value. *Cooling load* is the power required to remove heat from the product and lower its temperature to the target point while *holding load* is the power required to counteract heat gain from the environment once the product has reached the target temperature.[47]	Review manufacturer performance curves; calculate peak cooling load vs. holding load; confirm tropical derating
Accurate Storage Volume	Cold room size must match stock accumulation, dwell time and buffer capacity to prevent bottlenecks or under-utilization.	Apply storage formula and packing density; cross-check with turnover data and benchmarks from organizations like FAO and International Institute of Refrigeration (IIR)
Adequate Ice Production Capacity	Insufficient ice reduces the cold chain's ability to chill and preserve fish effectively, increasing spoilage risk, but over-sizing ice production creates unnecessary capital and operational expenditure.	Estimate daily chilled load; apply ice-to-fish ratio; validate with melt-rate assumptions for tropical climates
Energy System Compatibility	Energy supply through the grid, own supply or hybrid solution must meet total cooling load of freezers, cold rooms and ice machines; mismatched power leads to insufficient cooling and spoilage.	Conduct cooling load analysis; size PV/ battery systems; verify grid voltage stability

47 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

4.3 Cold chain technology selection and integration

Understanding the local context, operator and technician capacity and site viability are critical to ensure the selected cold chain technologies are aligned with the project's needs, location and value chain complexities. Contextual appropriateness ensures that the selected technology will work at installation and continue to operate reliably throughout its intended lifetime. Before choosing the technology, work through the considerations below to confirm feasibility and fit.

Validate that the preferred cold chain technology offers the required temperature control for the produce and markets served. Various fish species have different cooling parameters, and markets served have different temperature-control requirements. For example, tuna meant for export markets requires rapid freezing to maintain texture and grade, while small pelagics delivered to local markets rely heavily on ice slurry rather than rapid freezing.[48] Therefore, the selection of cold chain technology should align with the species mix and the markets to ensure cost efficiency and produce quality.

48 FAO. (1994). Freezing and refrigerated storage in fisheries.

Action*:* Thoroughly map the product and market needs and define the ideal cooling rate and storage temperature to meet the requirements. This information will be important for identifying the ideal cold chain technology to prevent spoilage, maintain quality and meet market demand.

For more information on understanding the produce species and food standards to support the decision-making process in identifying the ideal cold chain technology, please see FAO and WHO's Code of practice for fish and fishery products.

Consider refrigerant options. In selecting cooling technologies, the refrigerant selection is important consideration. Refrigerants are specialized working fluids in cooling systems that transfer heat by circulating between low-pressure evaporators (absorbing heat) and high-pressure condensers (releasing heat). By alternating between liquid and gas states, they enable cooling. Refrigerants are mainly classified into synthetic (HFCs, HFOs) and natural types (CO_2, ammonia, hydrocarbons), classified by their ozone depletion potential (ODP) and global warming potential (GWP). These refrigerants are regulated under the Montreal Protocol and Kigali Amendment, phasing out and down the production and consumption of ozone depleting substances and HFCs.[49] These international treaties are translated into national regulations on phasing out and down these refrigerants.

49 Multilateral Fund for the Implementation of the Montreal Protocol. (n.d.).

Action: Determine both the national regulation on the phase down of refrigerants (often with the Ministry of Environment or National Ozone Unit) and the proposed refrigerants in the selected cold chain technology to ensure compliance and long-term support.

For more detailed information on refrigerant selection, please consult section 4.8 of Walk-In Cold Rooms, A Practitioner's Technical Guide by Efficiency for Access.

Determine if the selected technology matches the local climatic and environmental conditions. The SWIO region's high temperatures, humidity and saline levels tend to increase the cooling load and reduce efficiency due to increased energy consumption, especially if not accounted for in the design.[50] Therefore, cold chain technology should be fitted with tropical-rated compressors, corrosion-resistant materials and adequate insulation to ensure they operate efficiently and offer ideal cooling output without damaging the technology.[51]

Action*:* Ahead of procuring the cold chain technology, assess the site-area environment to understand the temperature ranges, humidity levels and salinity levels. This assessment should also account for how these conditions may change over time, taking a climate-informed approach to technology selection. Use this information to evaluate options and select the appropriate technology, ensuring the equipment delivers reliable performance and longevity. **Table 11** shows the critical features that need consideration in the technology selection.

50 Can, J., et. al. (2021). Impacts of temperature and humidity changes on air-conditioning design load under climate change conditions in different climate zones of China. *Meteorological Applications*.

51 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Man showcases ice at an ice plant, Tanzania

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Sidi Nyanje (left) buys ice from Said Mkali, at the Takaungu Solar Ice Plant, Kenya

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Ice at Takaungu Solar Ice plant, Kenya

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Table 11: Critical features of cold chain technologies

Feature	Description or Rationale	Verification Method
Refrigerant selection	Ensure the selection of refrigerant with long term compliance to national regulations and service industry.	Review national regulations, evaluate proposed refrigerant for cooling technology and service
Tropical-rated equipment	Cold rooms, ice machines and freezers must maintain performance at 32–40°C external ambient temperatures within the region.	Review manufacturer technical sheets for temperature ratings, request client references with similar context
Corrosion resistance	Coastal salinity corrodes metals and electronics; the selected technology should have corrosion-resistant material particularly for ice maker machines.	Check for marine-grade stainless steel, coated coils, sealed electricals
Adequate insulation	Poor insulation increases energy use, reduces cooling efficiency, so selected technology should have sufficient insulation.	Confirm insulation thickness of the selected technology, client references and use case data can be helpful to assess suitability
Appropriate cooling rate	Technology must match species and market needs to ensure produce is maintained at the preferred cooling level.	Assess freezing rate (kg/hr) and ice production rate against landing data
Power compatibility	Equipment must align with grid or solar availability within the region based on project site location.	Evaluate grid stability, conduct basic load assessment, and discuss with manufacturer, further client references can be helpful

Assess that the technology matches the operational model's technical and managerial capabilities. For instance, does the team have capacity to operate, maintain and monitor the selected technology? Complex cold chain technologies are only suitable where the staff are trained accordingly on operations and monitoring.

***Action**:* Conduct a skills audit before procurement. If personnel capacity is low, prioritize modular cold rooms, flake ice machines, or solar direct-drive freezers and secure a service contract from a recognized refrigeration technician. Additionally, provide capacity-building training to equip the staff with operational skills for effective operations and proper monitoring mechanisms.

Determine if the site location is suitable for proper installation of the selected cold chain technology. Each of the cold chain technologies requires suitable infrastructure for installation, including access to water and energy (see Chapter 3). For example, a cold room maintains fresh fish at 0-4°C for short-term storage and requires modest ventilation, drainage and medium energy loads. Meanwhile, a freezer operates at -18°C or lower for long-term preservation and export quality, therefore demanding stronger ventilation, a larger insulated footprint and significantly higher, more stable power supply.[52] Beyond installation requirements, the site must be operationally viable, accessible to fishers and distribution vehicles year-round, and resilient to environmental hazards such as flooding, sea level rise and extreme weather.

52 FAO. (1994). Freezing and refrigerated storage in fisheries.

Action: Prior to selecting the cold chain technology, conduct a site readiness assessment to understand the ventilation, drainage, water access, energy sources and ground foundation to determine the safe installation of the selected technology and proper operations for effective utilization.

For more on proper installation techniques, please see Chapter 7: Planning for Installation and Long-Term Maintenance.

Map availability of maintenance support, including spare parts. A key consideration for long-term successful operation of the cold chain technology is access to reliable and trained technicians and spare parts.

Action: Assess the proximity and accessibility to all maintenance requirements to ensure reduced breakdown periods and access to quality spare parts. Before operations begin, the developer should identify and contract a qualified maintenance provider to secure access to specialized skills and spare parts.[53] Facility staff should handle routine tasks such as cleaning, lubrication and basic component checks, while specialized work, including refrigerant handling and compressor servicing, should be outsourced to the contracted provider. Additionally, the personnel should conduct weekly checks to identify any issues before they lead to significant difficulties.

53 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Assess sizing and utilization considerations for the technology selection. The selected cold chain technology should be sized based on catch landing periods, ideally with capacity to handle peak landings catch volume.[54] The developer should also assess whether the technology will be utilized sufficiently across the full season to support a viable business model. Sizing must further reflect the possibility that volumes will change over time, as environmental pressures may reduce catch while successful cold chain adoption may expand throughput. The supply analysis in Chapter 1 provides the baseline for both considerations.

Action: Leverage the seasonality assessment conducted (see Chapter 1's section on Seasonality Assessment) to identify the ideal size and capacity of the selected cold chain technology. This will ensure peak seasons catch volume is properly handled without any produce losses. Additionally, consider adding flexible add-ons such as secondary chillers to deal with short-term surges without incurring hefty costs on larger infrastructure.

Please see **Table 12** for a summary of critical conditions to consider for successful cold chain integration.

54 WWF. (2023). Scaling up cold-chain solutions in the Southwest Indian Ocean.

Joyce Ngala buys fish from a fish dealer in Takaungu

Table 12: Critical conditions for contextual appropriateness evaluation

Condition	Description or Rationale	Verification Method
Operator Capacity	The complexity of the chosen cold chain technology must match the operator's technical and managerial capacity. Sites with low-capacity risk downtime, unsafe handling and failures	Conduct a capacity assessment covering manpower, skills, and knowledge for operators and maintenance personnel; use identified gaps to determine training needs, additional staffing requirements, and whether a service contract is needed
Infrastructure Preparation	Successful installation requires adequate ventilation, drainage, water supply (for ice machines) and proper foundation. Poor infrastructure increases energy use, corrosion risk and operational failures	Perform a site readiness assessment; inspect ventilation pathways; test water quality; verify drainage and foundation strength; for greenfield operations, consider needs upfront
Maintenance Requirements	Reliable access to refrigeration technicians and spare parts is essential to maintain uptime. Remote sites without maintenance support face prolonged outages and high spoilage risk	Identify local technicians, verify spare-parts suppliers; review preventive maintenance plans and train in-house personnel on monitoring the technology
Seasonal Peak Capacity	Cold chain systems must handle peak landings, under-sizing of the cold chain infrastructure can lead to overload during peak seasons, causing losses	Cross-reference peak landing volumes from Chapter 1's supply analysis against the rated capacity of the candidate technology; apply a buffer factor to account for volume variability; confirm the technology can absorb peak loads without risk of overload or spoilage


Tima Ali, fish dealer in Kiwayu, weighs fish, Kenya

CHAPTER 5: DEFINING OWNERSHIP, GOVERNANCE AND OPERATIONAL MODEL

Identifying and establishing the right ownership and governance model for a cold chain project enhances the ability to deliver value to all stakeholders involved, drive performance of the cold chain project and ensure long-term sustainability. The long-term success of a cold chain, however, depends first and foremost on the people who use, support and operate it. Engaging local community leaders from the outset is therefore essential to understanding the motivations, needs and priorities that should shape ownership and governance decisions. Effective ownership, operational and governance models provide clarity on the roles, responsibilities, decision-making procedures and income distribution structure, which contributes to the probability of success and sustainability of the project.[55]

5.1 Ownership, governance, and management

Identifying the preferred ownership structure is critical in establishing and running sustainable and successful cold chain operations. Additionally, the ownership structure determines how the risks, responsibilities and financial returns are shared amongst stakeholders involved. Establishing a clear and well-aligned ownership structure ensures transparency, accountability and effective decision-making providing confidence in the governance of the project.

55 WWF. (2023). Scaling up cold-chain solutions in the Southwest Indian Ocean.

The majority of cold chain projects in developing country fisheries fail due to poor management and institutional management systems.[56] Projects with only communal interest but limited commercial or private interest have also frequently failed.

Implementing a competent and accountable ownership structure with clear governance and profit-sharing mechanisms, whether through a cooperative, private operator or beach management unit (BMU), is critical to the sustainability of the cold chain project and helps align incentives among all stakeholders. When combined with strong management, this ensures financial discipline, technical upkeep and transparent benefit-sharing, ultimately increasing the likelihood of long-term success for cold chain fisheries initiatives.

Cold chain projects operate within established political, institutional and regulatory frameworks that shape what is feasible. Fisheries, food safety, environmental and infrastructure regulations define the boundaries within which ownership and governance structures must be designed. Landing sites, energy supply and water infrastructure frequently fall under public sector management, making alignment with government priorities a practical necessity rather than a courtesy. Projects structured in accordance with prevailing policy frameworks are better positioned to secure government support, access public funding and sustain operations over the long term.

Determine who will own and operate the facility through a participatory process. The ownership structure should be developed in combination with clear governance policies and a team with a proven track record

56 WWF. (2023). Scaling up cold-chain solutions in the Southwest Indian Ocean.

of operating and managing blue economy related entities. Ownership decisions should not be imposed top-down. The developer should engage key stakeholders – including fishers, BMU representatives, private operators and relevant government authorities – from the outset to shape the ownership model collectively. This participatory approach ensures that the structure reflects real operational conditions, builds buy-in among those who will use and sustain the facility, and aligns with existing policy and governance frameworks.

Action: Convene a structured stakeholder consultation to present and assess ownership model options before a decision is made. Facilitate discussion of the trade-offs of each model in the local context, drawing on the following considerations: market and demand conditions, local management and business capacity, risk allocation and investment size, governance and incentives, and policy and institutional environment. Document the outcome of this process and the rationale for the selected model. **Table 13** presents a high-level overview of the main ownership models and compares them across selected key considerations. Once the ownership model has been selected, it needs to be formally registered in line with the statutory requirements of the country. Most importantly, while owners have "skin in the game" to incentivize them, employees do not. Aligning all incentive structures through shared ownership, profit sharing or performance-based bonuses can help encourage stakeholders to pursue common objectives together.

For more information on ownership structures for fishery value chains, please see NCRAC's Choosing an organizational structure for your aquaculture business *and* FAO's Primary survey of beach management units (BMUs) in Kenyan coastal marine fisheries. *Though these resources focus on the USA and Kenya respectively, most best practices that are transferable across the SWIO region.*

Three fishers show their catch after sorting, Tanzania

Table 13: Ownership models

Model Type	Key Strengths	Typical Geography	Potential Risks	Best Fit For	Investor Considerations
Community cooperative (BMU/LMMA/CCP-linked)[57]	Locally driven with strong local buy-in Supports inclusivity and resource stewardship Profits are reinvested locally	Common in nascent or remote markets where BMUs, CCPs or LMMAs are active (e.g., Kenya, Tanzania, Mozambique and Madagascar)	Could experience weak financial discipline with financial decisions Are exposed to the risk of elite capture due to inequitable partnerships Single BMUs are typically too small to be commercially viable	Small artisanal fisheries with organized BMUs Nascent markets that have low operations and maintenance	Financial records and repayment discipline Collateral owned by the cooperative
Private (Small and medium enterprise) SME ownership	Independently operated with professional management Has faster decision-making process with strong commercial inclination	Ideal in established markets where there is high throughput, commercial landing sites and processing sites (e.g., Mombasa, Kenya or Diego Suarez, Madagascar)	Risk of excluding small fishers as they focus on volume to meet demand Could focus on profit over sustainability	High-volume landing sites or integrated fishery value chains Established markets with high volume demand	Clear credit and financial records Ability to provide collateral Easier to structure loans or equity due to defined ownership and revenue visibility
Public-Private Partnership (PPP)	Balances social and commercial outcomes bringing the private and public sector actors together Government retains oversight and in some cases control The operator manages efficiently	Present in growing/ intermediate markets with commercial activity but limited private capital (e.g., Tanga sites in Tanzania)	Tend to have complex contracting mechanisms Risk of unclear accountability and responsibility	Sustainability focused donor-funded or government-built facilities Established markets with high volume demand	Shared risk between public and private partners increases confidence Long-term concessions and/or guaranteed offtake can assure predictable cashflows Risk of political interference
Cooperative partnership with a private operator	The cooperative retains ownership while private operator manages the project under an agreement Allows for blended community control with efficiency	Common in growing/ intermediate markets with improved structured operations (e.g., Morondava landing sites in Madagascar)	Requires robust contract management and trust-building between the cooperative and the private operator	Transitional projects aiming for long-term community takeover Growing markets that have increased demand and quality requirements	Balanced model combining community and private sector engagement Bankable if private operator manages cashflow and maintenance Risk of sustainability in the event of change in the private operator

57 Note: Beach management units (BMUs) are present in Tanzania and Kenya; in Mozambique the equivalent community level organization is Conselho Communitária Pesqueira (CCP) Transfert Gestion des Resources Halieutiques (TGRH) in Madagascar.

Confirm the management team possess the technical, financial, business and leadership skills to oversee operations. The management team should bring strong relevant experience in fisheries and ideally cold chains, paired with technical skills relevant to the project, spanning project management, sales and marketing, financial management, fundraising, logistics and FMCG operations. The team's skills should be complementary, and any remaining gaps should be filled through additional hires. Management and personnel with limited cold chain experience should obtain relevant training or be willing to undergo it. Training should cover not only technical cold chain operations but also leadership capability, the mindset required to drive continuous improvement and the skills to work effectively with stakeholders across the cold chain. More sophisticated cooling technologies require dedicated engineering capabilities only when professional maintenance expertise is not readily accessible.

***Action**:* Ensure personnel are trained on cold chain operations and key business management aspects. Ideally, the senior team should bring university studies in business, plus many years of experience supporting similar projects and ventures. For the broader team, be sure to have training materials available, plus willingness to learn via trainings and refresher courses.

For more details on fishery management techniques, please see FAO's Guidebook on evaluating fisheries co-management effectiveness. *For an example of management in a fishery value chain, please see* FAO's Management procedures for sustainable tuna fisheries.

Validate that the ownership and incentive models ensure community engagement. Governance structures should clarify how community stakeholders can actively participate in and benefit from the cold chain. Decisions should be grounded in user needs from the outset and embedded into design, operational and governance processes.[58] The developer should maintain transparency with community stakeholders on fair revenue share agreements, off-taker agreements and equipment requirements, as well as train involved parties on relevant best practices. Community shareholding and other incentive mechanisms will reinforce this alignment, but the governing objective is shared ownership and collaboration, not control.

Action: Engage local community leaders from the start to understand their motivations and how best to support local growth and opportunities. For community buy-in and incentive alignment, it can often be helpful for the local community to have some level of 'skin in the game'. Maintain transparency and clarity concerning ownership, management, financial systems and stakeholder incentives to build community trust and support, which is critical for a successful and sustainable project. Also, ensure there is a strong monitoring system to track community impact, and that they see it (e.g., jobs, increased incomes, revenues going to public goods, etc.).[59] Introduce regular community engagement forums and maintain an open feedback loop with the community (e.g., a monthly meeting to discuss progress, risks and mitigations as well as solicit feedback).

58 WWF. (2023). Scaling up cold-chain solutions in the Southwest Indian Ocean.
59 WWF. (2019). Fisheries co-management.

For a good example of community engagement, please see: the Kenya Coastal Development Project (KCDP), where beach management units (BMUs) were formally engaged before the installation of community-run ice plants. They held early-stage consultations with BMU leaders, women's groups and youth traders to understand local priorities such as improving income stability, reducing spoilage, and creating jobs. Financial transparency was established by co-developing simple revenue-tracking tools and displaying monthly financial summaries publicly at landing sites.

For more details on community engagement and governance, please see FAO's Guidebook on evaluating fisheries co-management effectiveness.

Choose a governance structure which best promotes transparency and accountability. An effective governance structure requires a representative body that oversees the strategic decision-making and management team, such as a Board of Directors and/or equivalent group for resource allocation and reporting. This should include a clear governance charter that stipulates management roles, voting structure and reporting frequency, including requirements for sound financial systems and internal controls, as well as stakeholder incentives.

Action: Based on the ownership and operational structure, determine who are the key stakeholders (e.g., investors, BMUs, private operators, etc.) to establish a governance committee with fair community representation (e.g., >30%) and clear roles and responsibilities. Set up a clear governance framework with strong ethical guidelines, especially around financial and impact reporting as well as stakeholder meeting cadence.

For more details on community governance, please see WWF's Fisheries Co-Management.

Determine the key governance practices which are required for smooth and long-lasting operations. Establishing and communicating strong governance practices helps to ensure that policies are consistently followed in day-to-day operations. The governance committee will provide strategic guidance and oversight to the management team who will develop standard operating procedures (SOPs).

Action: Develop a simple management handbook that outlines all key operational processes and performance targets. Embedded digital management systems will ensure transparency and accountability is maintained in monitoring day-to-day financials and operations of the facility.

For more details on governance practices, specifically around principles for policy design, please see OECD's Handbook for fisheries managers. *Please also see* FAO's voluntary guidelines for securing sustainable small-scale fisheries, *which address both inclusive governance principles as well as value chains and post-harvest loss reductions.*

Takaungu Solar Ice plant

Kiwayu Solar Ice plant

Table 14: Critical conditions for a suitable governance structure

Condition	Description or Rationale	Verification Method
Financial transparency	Regular reporting and disclosure of revenues, expenditures and maintenance funds build user trust and attract investors	Audit reports, public financial summaries, meeting records
Establishment of governance policies	Documentation of representation of stakeholders to strengthen fairness and long-term legitimacy	Committee membership lists, bylaws, meeting minutes
Operational performance tracking	Key performance indicators (KPIs) such as utilization, uptime and fee collection ensure accountability and efficiency	Monthly dashboards, operational logs, digital monitoring tools
Community feedback and grievance mechanisms	Open communication channels enable early issue detection and continuous improvement	Meeting notes, feedback registers, surveys, consultation reports
Digital management system	Data-driven performance management, including financial and operational metrics, improves speed of access, quality assurance and decision-making.	Daily, weekly or monthly digital performance reports with underlying system logs and data reports
Leadership capability	Strong leadership ensures governance structures translate into action, with leaders able to drive performance, build stakeholder trust, manage conflict, and sustain community engagement over time	Leadership competency reviews, stakeholder feedback surveys, records of leadership training completed by management and governance committee members

As a development partner, confirm the project has a governance and operational structure suited to SWIO realities. Governance challenges in the SWIO region are common, such as weak cooperative governance, limited technical operator capabilities, unclear ownership and management structures and high reliance on BMUs or similar structures. Investors should analyse the selected operating model, operator track record and accountability mechanisms carefully. Critical governance success factors include transparent revenue-sharing agreements, clear decision rights, clear ownership structures, relevant and timely reporting of key performance indicators (KPIs), as well as asset security in case of theft or extreme weather.

Action: Evaluate the governance and operational model to ensure there is clear documentation of roles and responsibilities, governance mechanisms, revenue-sharing agreements and compliance with regulations. Further, evaluate the operator's track record, and ensure accountability mechanisms and standard operating procedures are in place and actively implemented. Furthermore, assess whether the project has invested in building leadership capability and operational mindset across the team, prioritizing competence and commitment over compliance, and fostering a culture of continuous learning to strengthen cold chain performance over time.

5.2 Selection of operating model

The selection of the operational model determines what activities the project conducts, its revenue model and how day-to-day activities are coordinated among stakeholders. Identifying the ideal operating model to fill the most pressing market needs, while aligning with capabilities available, will create the highest probability of success. Follow these simplified initial steps:

1. **Identify what problem needs to be solved:** Start by identifying the market gap that needs to be addressed. Does the fishery mostly just need access to ice or cooling services, or is a larger effort to consolidate supply and demand needed to truly expand the value chain and livelihood opportunities?
2. **Understand the customers and their needs:** Which customer segments are mostly affected by the market gap? what exactly are their pain points, and how are they currently addressing them?
3. **Articulate the value proposition:** First, identify how to address the customer's 'pain point'. Then, using human-centred design, identify a unique proposition and positioning in the market.
4. **Develop the project and operating model:** Define the operational model best suited to deliver the identified value proposition, and ensure all functions and activities are integrated to best pursue the strategic objectives.
5. **Pilot and refine the operating model:** Identify and test key assumptions and hypotheses to first pilot and then continuously refine the operating model.

Assess which gaps in the value chain need filling (e.g., if there is an anchor sourcing partner). Every operating model requires a value proposition and its own unique linkages across the supply chain. The supply and market analyses completed in Chapters 1 and 2 provide the foundation for this assessment. Both the 'market need' and the market linkages need to be analysed on a case-by-case basis. For example, cooperatives will often pull together produce in bulk volumes by organizing and coordinating fishers, aggregators and processors. Sourcing from a cooperative then implies that fewer direct relationships have to be managed, as the cooperative creates a central point of interaction. However, they often hold significant bargaining power. In the absence of a cooperative or similar grouping structure, the project might be required to have many relationships with different stakeholders to access the required volumes of produce. The activities and capabilities of the sourcing partner, off-takers and other market stakeholders will determine what type of operations have the highest potential of unlocking volumes, growth and impact within the value chain, which will then inform the choice of operating model.

Action: Drawing on the supply chain mapping and market demand analysis from Chapters 1 and 2, analyse the supply chain to understand gaps and opportunities for strategic partnerships, and where the gaps are that need filling (e.g., just selling ice, or operating cold chain facilities as a service to a cooperative, *versus* setting up full fish trading operations). Consider developing a stakeholder mapping and risk management framework to help identify the project's core mission, and for tracking of further intervention opportunities.

A local fisher sorts through fresh squid on the beach before selling. MafiaIsland, Tanzania.

A woman sorts through fish for selling. Mafia Island, Tanzania.

Fisher 'Billy' standing on his boat holding a common carp, Lake Naivasha, Kenya.

Based on the target value proposition, select the most suitable operational model. The value proposition fills a critical gap based on what the customer needs and what is already offered in the market. Then, under consideration of the available capabilities and resources, the decision on operating model can be made. For example, if the fishery is operated by a well-managed anchor partner (e.g., a cooperative or BMU) that already successfully consolidates supply, manages sustainable fishery practices, and has established scalable market linkages, the operating model can focus purely on the cold chain aspect. In this case, ice sales (for smaller projects), or Cooling as a Service (CaaS) might be best suited to fill the market gap. These operating models also require significantly less capital than setting up a fish trading business (e.g., push or pull models), as the responsibility for working capital – like financing for inventories and fish trade receivables – remains with the anchor partner. In contrast, a less organized fishery community, characterized by many individual fishers or smaller groupings, will likely require more significant coordination and support to be successful, such as establishing of a fish trading business. Besides the market context and available resources and capabilities, the ownership structure often also impacts the choice of operating model. For example, in a producer-owned operational model, such as a beach management unit (BMU)-led project, the local fishers, traders and other community stakeholders collaboratively manage local fisheries resources. This model entails pooling together resources to source, handle, process, store and distribute the produce to target markets, allowing the community to improve their bargaining power and increase incomes. In this instance, the current scope of activities of the existing operating model will likely predetermine the future operating model, which then gets expanded to also include cold chain operations. Also, other key market players, including off-takers, might have strong preferences influencing the operating model (e.g., only offering Cooling as a Service at the landing site may not be seen as a sufficient quality guarantee).

Action: Drawing on the site viability and intervention design assessments from Chapters 1–4, determine what will be most critical for success: pure cold chain operations, sales and marketing capabilities, logistics know-how, access to finance, community engagement, impact or something else. This, combined with an understanding of market needs and internal capabilities, will then provide helpful clues into what operational model to select, how to staff the management team, and where to prioritize resources. Do not advance to model selection before these assessments are complete and prioritize the management capabilities that the assessment identified as the critical gap.

For simple business/operating model development, the business model canvas *is a helpful tool. A strategic tool for developing new business models or documenting/improving new ones, it provides provides a “one-page overview” of all the core elements that define a business.*

Table 15 and **Table 16** provide an overview of different operational models in fishery cold chains. Please note that they are not exclusive to each other, and one project can often combine several of these models. First, let's take a look at classic fish trading models:

Table 15: Overview of pull and push models

Operating Model	Definition	Pros	Cons	Capacity Requirements	Fit by Market Maturity
1. Pull model **Chain organizer/ aggregator-led[60]**	A central enterprise aggregates fish from multiple landing sites and coordinates cold storage, logistics and sales downstream. Demand is "pulled" through the system by an organizer who secures off-takers and guarantees volume.	Strong quality control critical for successful pull High utilization of cold chain assets Attractive to investors due to predictable volumes and revenue	Requires strong management capacity Higher operating costs for aggregation and logistics Risk if lead buyer withdraws	Skilled operations and logistics teams Strong networks and ideally contracts with fishers and buyers Digital systems for traceability and payments	High maturity (existing aggregators, stable markets, reliable volumes)
2. Push model **Producer-owned or cooperative-run[61]**	Fishers or community cooperatives jointly manage the cold chain infrastructure and "push" product to market through collective bargaining and shared services to secure off-taker agreements.	Strong community ownership and benefit-sharing Lower pricing for members Better alignment with livelihood objectives	Lower managerial capacity Risk of weak governance and inconsistent operations Limited ability to scale or meet strict buyer standards	Basic financial management Cooperative governance structures External technical support for maintenance	Low to medium maturity (strong BMUs/cooperatives, moderate volumes)

60 Cold Solutions Kenya. (2025). A stronger cold chain for Kenya's smallholder farmers starts with smarter aggregation.
61 Efficiency for Access. (2023). Assessment of the cold chain market in Kenya.

The next table provides an overview of selected, common operating models with cold chain aspects being more central to the value proposition:

Table 16: Overview of alternative cold chain-focused operating models

Operating Model	Definition	Pros	Cons	Capacity Requirements	Fit by Market Maturity
1. Cooling as a Service (CaaS)[62]	Users pay per unit of cooling (per kg, per crate, per day), rather than owning equipment. The operator owns, maintains and manages the entire cold chain system	Low upfront cost for fishers High-quality service delivery Limited working capital required Predictable revenues when larger client commit	High CAPEX burden on operator Small margins, often unpredictable business Requires reliable billing systems	Advanced technical capacity Mobile/digital billing systems Skilled technicians for uptime management	Medium to high maturity (reliable demand, digital payment readiness, SME presence)
2.Third party logistics (3PL)/refrigerated distribution[63]	A logistics provider who offers cold storage and transportation services to fishers, processors and traders	Expands market reach beyond landing sites Flexible and scalable Improves traceability and quality	Requires high logistics coordination Expensive for small-scale users Revenue depends on consistent volumes	Fleet management Refrigeration expertise Route optimization systems	Medium to high maturity (urban markets, tourism, export corridors)
3. Mobile cold chain **Motorbike coolers, mobile ice units, boat coolers**	Mobile cold-storage solutions that deliver cooling directly to landing sites or remote communities where fixed infrastructure is not available	High reach in remote areas Low CAPEX compared to fixed infrastructure Reduces immediate post-harvest loss	Lower cooling capacity Limited to short-term storage Less energy efficient	Mobile operators Basic training for handling cold units Light servicing capacity	Low maturity (dispersed landings, low volume, off-grid contexts)
4. Ice sales	Ice sold as a cooling medium, usually over the counter; different ice types offer different cooling properties, e.g., flake ice, slurry ice, or block ice.	Often significant demand Easy to operate Low CAPEX Diversified uses and customer segments	Short-term storage only Small margins, and requires economies of scale Energy requirements drive costs	Limited operator capacity required Access to energy and water sources Light servicing capacity	Low maturity (dispersed landings, low volume)
5. Community-owned shared facility (BMU or cooperative	BMUs or fisher cooperatives collectively own and operate fixed cold chain infrastructure. Fishers and traders are both primary users and co-owners of the assets, retaining ownership of their produce throughout the value chain.	Full asset and produce ownership retained within the community Profits flow directly to members Strong user-owner alignment Supports collective bargaining	Requires strong cooperative governance Risk of elite capture Limited commercial capital access Management capacity often constrained	Cooperative governance structures Basic financial management Technical training for operations and maintenance	Low to medium maturity (organized BMUs or cooperatives with sufficient landing volumes to justify shared fixed infrastructure)

62 CaaS Initiative. (2022). Servitisation of the cooling industry: Cooling as a Service (CaaS).

63 Global Cold Chain Alliance. (2018). Kenya cold chain assessment.

CHAPTER 6: ENSURING FINANCIAL VIABILITY

Too many cold chain investments are not commercially viable and then struggle with sustainability. Conducting thorough upfront financial planning and projections is a critical step to have a full understanding of economics and sensitivities. Financial modelling will further help in providing transparency on break-even throughput volumes, investment requirements, cashflows and financing needs.

6.1 Financial analysis

Presenting a strong financial case demonstrates that the proposed cold chain project is commercially viable, operationally sustainable and investable. In this section, we aim to introduce financial management and guidance for the financial analysis and capital needs assessment. **Table 17** presents some important basic financial accounting terms for reference. Please also refer to the Template Financial Projection Tool provided in the Tools and Appendices of this playbook.

Table 17: Overview of basic financial accounting terms

Term	Definition
Revenue	Total income generated from selling goods or services before any costs are deducted
Cost of goods sold (COGS)	Direct costs attributed to producing the goods or services sold
Operating expenditure (OPEX)	Recurring costs required to run the business day-to-day
Gross profit	Revenue minus direct costs (COGS) incurred in generating that revenue (e.g., energy to run ice machines)
EBITDA	EBITDA stands for earnings before interest, taxes, depreciation and amortization a measure of operational performance and proxy for cashflows
Depreciation	Reduction in the value of an asset over its useful life due to wear and tear
Net profit (or net income)	Profit remaining after deducting all expenses, including OPEX, taxes, depreciation and interest
Capital expenditure (CAPEX)	Upfront capital investment required to acquire or construct long-term assets (e.g., the investment in cold chain technology)
Cash flow	Movement of money into and out of the business, determining liquidity and ability to meet obligations
Working capital	Funds required for day-to-day operations, covering inventories, accounts receivable, and accounts payable, e.g., short-term obligations such as salaries or energy
Variable costs	Expenses that change with production levels (e.g., energy for ice-making)
Fixed costs	Expenses that remain constant regardless of production (e.g., salaries, rent)

Revenue Drivers

Understand the main sources of revenue for cold chain projects. Determining the off-takers and the volume of produce they purchase, and at what price, is the basis for projecting revenues. Revenues can be generated from different products and services in the value chain, such as ice sales, cold storage fees or fish sales.

***Action**:* Assess each off-taker's estimated monthly purchases by product, product type (e.g., fresh, chilled or frozen), quantity and price; ideally, estimates are based on letters of intent signed with off-takers. Include volumes and prices in the Template Financial Projection Tool's revenue section to calculate projected revenues. Consider diversifying revenue streams across off-takers, products and services to manage seasonality and off-taker dependence.

Determine pricing structure based on costs, market prices and positioning. Pricing based on actual market prices (e.g., price per kg of fish, or a daily fee for cooling as a service) is the easiest approach and often sufficient for the sake of initial financial modelling. However, competitive market prices are only one consideration. Often, seasonal price fluctuations, internal cost structures, market realities (such as affordability) and even brand positioning should also be factored into pricing.

***Action**:* Base your financial projections on historical price averages and seasonal fluctuations to ensure the business stays profitable year-round; it's always advisable to err on the safe side in financial modelling! Since fish prices are highly sensitive and difficult to raise unless there is a clear way of differentiation, so focus on keeping your operating costs low enough to cover them even with conservative price estimates.

Cost Drivers

Determine the major cost components. Establishing a cold chain project will likely incur capital expenditures (CAPEX), raw material costs and operational expenditures (OPEX). CAPEX includes the upfront investment in facilities, including cold chain technology, and CAPEX is usually depreciated over its expected lifetime. Raw material costs are the costs incurred for sourcing the revenue-generating products. OPEX, in contrast, covers the day-to-day operating expenses and overheads.

***Action**:* Obtain at least 2–3 supplier quotations for key CAPEX items to confirm CAPEX assumptions. Raw material costs should be researched through price discussions with fishers and/or other methods. Then, OPEX costs should be based on realistic estimates, ideally leveraging comparables, including salaries, wages, rent, telecommunications, electricity, water, packaging, insurance, marketing, logistics and maintenance (unless a large component is replaced, in which case it would likely be CAPEX).

For the cold chain technologies, include maintenance costs and depreciation. CAPEX items are shown on the balance sheet and will be depreciated against their expected useful lifetime, recorded as an expense in the income statement. Depreciation represents the gradual loss of value of fixed assets. Accurate projections for both depreciation and maintenance provide more accurate financial forecasts to ensure operational continuity and prevent unexpected costs due to breakdowns.

***Action**:* Include depreciation and maintenance costs within the financial projections for accurate financial planning. The lifetime of different assets can be found in commentaries for different financial reporting standards, like IAS 16 Property, Plan and Equipment for countries where International Financial Reporting Standards (IFRS) apply, subject to local statutory regulations. Equipment lifetimes will likely range from 1–2 years for smaller or short-life technologies and to up to 8–12 years for large items like cold rooms. Include assumptions on maintenance and spare part costs in the financial projections to prevent liquidity crunches.

For additional information on best practices related to maintenance cost planning and depreciation, kindly refer to FAO's Finance of freezing and cold storage.

Financial structure

Determine which financing option best fits the selected ownership models. Available financing options will often depend largely on ownership structures and operational capacity to generate revenues and free cashflows, manage repayment risks and deliver returns to investors. Different financing and ownership structures will have implications on produce affordability, inclusivity and financial accountability. For example, community-led projects tend to rely on grants or concessional funding with favourable terms, while private-sector led projects tend to utilize equity, commercial debt and/or various forms of blended finance, sometimes including results-based financing, to fund their growth. They are often required to generate returns for the shareholders. Please see **Table 18** for more information on how financing options differ based on ownership models.

Action*:* Evaluate the financing options, taking into consideration the ownership and operational model, to assess which financing options are the best fit. Often, a blend of financial products will be beneficial, such as grants to setup and scale small scale fisher engagement, equity to finance CAPEX and some concessional debt to finance working capital. As relevant, ensure the project can meet repayment obligations and/or provide returns to investors.

Often a mix of financing products are needed. To learn more about blended finance, please see Convergence's Report on blended finance.

Two fishers show their catch on shore, Tanzania

© EGNO NDUNGURU / WWF TANZANIA

Table 18: Common financing options based on ownership model

Ownership Model	Typical Financing Instruments	Rationale (Why This Financing Fits the Model)
Community-led (Cooperative/BMU-linked)	Grants Concessional loans Results-based financing (RBF) Small working-capital grants or loans	Community-led models often lack collateral, credit history, or strong financial management systems, making commercial lending high risk Grants support affordability and social inclusion (women, youth, low-income fishers) Concessional debt allows gradual repayment, often patient, and aligned with seasonal cash flows RBF incentivizes performance towards desired outcomes (e.g., increasing number of fishers engaged, reduced PHFL)
Private SME ownership	Equity (seed, impact or commercial investors) Commercial debt (bank loans, asset-finance structures) Blended finance (concessional and commercial capital) Results-based financing (RBF)	Have clear management structure, stronger revenue predictability and collateral for borrowing. Commercial debt that can leverage contracts with off-takers to demonstrate repayment ability Equity supports scale and expansion Blended finance attracts private lenders by lowering risk, and RBF aligns interests on desired outcomes
Private-public partnership (PPP)	Public capital (infrastructure grants, land, CAPEX) Private commercial debt or equity for operations Blended capital for shared-risk investment	Public sector de-risks infrastructure investment, enabling private operators to manage efficiency Require structured financing since revenue streams are often regulated or tariff-controlled Blended capital derisks investments to crowd in private capital, and supports initial scaling and long-term viability
Hybrid cooperative + private operator (lease-to-own/management contract)	Grant-funded infrastructure paired with private operator capital Concessional loans for equipment Performance-based contracts (RBF) Blended finance for transition to full community ownership	Community retains ownership while private operator ensures efficiency and financial discipline Grant support keeps services affordable; private capital strengthens management and reduces operational risk RBF promotes joint accountability for performance outcomes (e.g., reduced post-harvest losses) Blended instruments support cooperative capacity-building and eventual ownership transfer

Based on the financial projections developed, forecast how much project financing is required. Financial projections and budgets should be monitored regularly, ideally at least on a monthly basis, to estimate cashflows and consequently how much external capital is needed, and when. Conducting a robust analysis founded in local context and research will help ensure the financial projections reflect realistic costs, risks and operational conditions to help inform management planning and enhance investor confidence.

***Action**:* To clearly identify the project financing needs, you need a full picture of both revenue and costs over an extended time period. Using the financial projection tool, estimate the cold chain project financing needs by combining CAPEX, working capital needs and a contingency reserve. This will help fully capitalize the project through construction, installation, operationalization and the ramp-up period. Manyventures fail because of liquidity issues rather than a lack of profitability, so beyond upfront financial projections, ongoing cash budgeting is critical to success.

Assess cashflows related to the capital structure to promote project sustainability. As the preferred financing option is selected, consider repayment terms and return expectations. These directly impact the project's liquidity, operational resilience and investor confidence, particularly if seasonality of fishery value chains impacts cashflows. Often, negotiating grace periods can be beneficial when operations need to first ramp up.

***Action**:* Negotiate financial repayment terms that align with the seasonal revenue cycles and projected cashflows of the project to ensure proper management of the project's liquidity and ability to meet repayment terms; embed repayment schedules into the financial projection model.

Leverage financial modelling to help secure financing. Externally shared financial information and projections should be based on the internal financial projections and analysis which aligns project assumptions with market expectations and trends. Properly structured financial models are key in demonstrating the project's commercial viability, cashflow situation and long-term project sustainability. A robust financial model presented to financiers should 1) consider the ownership and operational structures, 2) project realistic revenues and costs, and 3) allow the user to simulate the impact of financing structures on returns and cashflows.

***Action**:* External-facing financial models should communicate the project's commercial viability, cashflows and long-term project sustainability to investors. Build realistic revenue projections and costs to build trust in the outputs and have visibility of what likely lies ahead, which is key to setting up for success.

For more details on how mobilize investment, see IFC's Cooler finance report.

6.2 Interpreting financial outputs

Having a financial projection model is the starting point. Reading and understanding its outputs is critical for shaping strategic and operational decision-making as well as maintaining a competitive advantage.

Calculate the minimum turnover required to reach profitability. It is critical to understand the project's minimum volume turnover – often known as break-even sales volume – to reach profitability. Confidence in reaching that target volume is key to achieving commercial viability.

Action: Make sure the projected break-even volume is achieved to cover fixed and variable costs of the project. Ideally, plan in a cost buffer as projections are often on the optimistic side. Understanding the throughput volume that needs to be achieved will also allow the assessment on which and how many off-takers are needed to support break even and growth.

Forecast the capacity utilization rate and inventory turnover times needed to break even. In addition to the turnover required, another interesting angle is required cold chain utilizations rates, combined with turnover times, to break even. This can help with assessing the economics of the business as a whole, or to better understand the payback periods on certain assets. Evaluate the near-term utilization rate and estimate what utilization rates and turnover times are needed in future to break-even and hit financial targets.

Action: Calculate the expected capacity utilization rate based on expected storage capacity, sourcing volumes and inventory turnover times. Sourcing volumes and inventory turnover times allow you to calculate sales volumes and consequently revenues, which then enables you to assess different scenarios of what capacity utilization rate and or inventory turnover time is needed to break even. Holding inventory turnover and all other assumptions constant, you can calculate the capacity utilization rate where revenue equals total costs. Review both supply and demand expectations to ensure they can sustain this utilization rate, even among low seasons.

Besides understanding unit cost economics, also assess the cost per unit of cooling. Establishing the cost per unit of cooling provides insights into the unit-level margin impact from technology investments, and multiplied with volumes, the impact on the project. This is important to analyse, as it impacts the overall costs of the business, and can provide useful insights for management decision-making.

Action: Calculate and track the cost per unit of the cold chain infrastructure to evaluate operational efficiency and pricing. Determine the cost per kilogram for produce stored by dividing total cooling OPEX by total cooled output over the same period. Then, track this metric monthly to better recognize patterns within energy efficiency and storage downtime due to seasonality and handling efficiency. Assessing this will help identify operational inefficiencies, adjust pricing to cover costs and optimize utilization.

Table 19: Key assessments to consider in financial projections

Assessment	Description or Rationale	Verification Method
Break-even point	Sets the minimum operational threshold required to recover total costs and informs revenue/performance targets	Review of scenario analysis outputs, the break-even point is the sales volume where revenues equals costs
Cost-per-unit tracking	Monitors efficiency by expressing total OPEX per kilogram or crate handled	Monthly performance dashboard, energy and volume logs
Scenario and sensitivity analysis	Demonstrates project resilience to changes in price, energy cost and seasonality; essential for investor due diligence	Targeted adjustment of key revenue and cost drivers in the financial projection tool to understand critical levels

Beyond the above, financiers will use their own set

of indicators to assess investments stress-test the assumptions made in financial projections. Different types of financiers have different interests. Grant funders will presumably mostly be interested in impact outcomes, while equity investors will want to see capital gains and or dividends, and debt financiers will want cashflows to ensure timely repayment. Generally, financiers will carefully assess the key drivers within the financial projections, both on the revenue and cost side, checking that projected volumes, prices and costs reflect realities on the ground. For any trade financing structures, they will also want to understand the reliability and creditworthiness of the off-takers.

Action: First, understand what the key interests of the financiers are (e.g., impact vs. growth vs. predictable cash-flows). The project's "pitch" needs to address those key interests and the key underlying indicators. While developing financial projections, always try to remain objective and conservative across all key assumptions to ensure they are defendable. Additionally, explore the project's exposure to currency risk – local currencies fluctuate, which can lead to higher perceived risk for the financiers if the investment is in hard currency. Please see the below table of critical topics for investor conversations.

Table 20: Critical conditions for investor assessments

Condition	Description or Rationale	Verification Method
Verified market	Ensures project is grounded in real coastal and island landing volumes and seasonal fishing patterns	Review landing site records, BMU/cooperative logs, monsoon-based seasonal modelling and willingness-to-pay surveys; signed letters of intent from off-takers, etc.
Operational and governance structures	Developed governance structures and processes; (e.g., aligned with BMU governance frameworks and avoids community disputes)	Review governance agreements, BMU approvals, revenue-sharing structures and alignment with fisheries regulations
Stakeholder inclusion	Ensures buy-in from fishers, BMUs, cooperatives and local authorities	Review stakeholder engagement reports, MoUs and conflict mitigation mechanisms
Regulatory compliance	All regulatory requirements need to be met, without any exposure risks. Fisheries landing, coastal zoning and MPA restrictions differ across SWIO states	Check permits, land use approvals and compliance with fisheries and coastal environment regulations, as well as all other applicable regulations

Said Adnan, a fisher in Kiwayu, drying his fish at Kiwayu landing site, Kenya

PROCUREMENT AND IMPLEMENTATION GUIDANCE

Proceeding from intervention design to implementation, successful execution requires procuring quality equipment, deploying it correctly and maintaining it consistently over its operational life. It equally requires demonstrating measurable outcomes to the funders and communities the project serves. After completing this section, the reader will be able to deploy cold chain technology effectively and manage project impact with the discipline that long-term viability demands. Chapter 7 guides the developer through the full procurement cycle, from technical specifications and supplier selection to installation oversight and long-term maintenance. Chapter 8 provides the frameworks to measure impact across economic, social and environmental dimensions and communicate results to funders, partners and local communities.

CHAPTER 7: PROCURING THE COLD CHAIN TECHNOLOGY, INSTALLATION AND ONGOING MAINTENANCE

Once the right cold chain technology is determined to meet the project's needs, it's time to assess the different available procurement options. These can include outright purchases, or alternatively financial lease agreements or operational lease agreements, where the equipment is borrowed often at considerable cost. For projects in which fish volumes are insufficient to justify any form of equipment ownership, the developer should instead consider connecting to an established trader, logistics provider or Cooling as a Service operator. This chapter focuses on outright purchase of cold chain technology; however, many of the principles equally apply to lease agreements. Proper procurement procedures ensure that the selected cold chain technology is fit for purpose, meets the required equipment specifications and comes from a reliable supplier to deliver and install the equipment.

Planning for installation and long-term maintenance is critical to ensure long-term operational sustainability. While hardware selection and deployment determine initial performance, installation and continued maintenance will ensure longer term project success and return on investment.

This chapter provides guidance on developing procurement specifications tailored to cooling systems, evaluating suppliers and choosing the most suitable procurement approach, followed by guidance on how to plan for installation and long-term maintenance.

7.1 Developing procurement specifications

The process of developing the procurement specifications helps ensure all aspects of the acquisition and product-supplier selection are considered, like performance, environmental durability, installation requirements and service obligations. Further, fully articulating these specifications is important for holding the supplier accountable.

Define the procurement specifications to meet the project's requirements. Developing procurement specifications begins with the selected cold chain technology and the more specific technical requirements, including capacity, temperatures, refrigerants, etc. The procurement specifications of the selected cold chain technology should be aligned with regulation standards for the selected technology (e.g., *see* ISO 5149-1:2014 Refrigerating systems and heat pumps*)*.[64]

Action: Identify the key performance requirements of the selected cold chain technology. Most of the requirements should be quantifiable metrics to reduce ambiguity, such as temperature range, cooling output and equipment capacity. These can be captured in the Procurement Specifications Template, available in the Tools and Appendices. Request equipment technological specifications and test reports from the supplier to confirm that the performance of the equipment matches the required specifications.

For more information on cold chain technology requirements for freezing and refrigerated storage, please see FAO: Technical Paper 340.

Incorporate environmental & operational conditions into the procurement specifications. Cold chain projects across the SWIO region require technologies that

64 ISO. (2022). ISO 5149-4:2022 Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4.

can withstand high humidity, salinity and unreliable power supply. It is imperative to have a deeper understanding of the local climate and the impact it will have on technologies (please see Chapter 4: Selecting the right cold chain technology).

Action: Ensure to clearly specify the environmental and operational requirements. Request suppliers to provide material specifications proving suitability for project site conditions. For instance, the selected cold chain technology should be designed for ambient temperatures with corrosion-resistant materials that can withstand conditions such as high humidity levels. They will need sufficient ventilation to handle high temperatures, adequate drainage capabilities and electrical components adapted to the local energy situation (e.g., on-grid, off-grid, hybrid).[65,66] Further, available water volumes and quality need to be captured in the specifications.[67]

Further considerations and information regarding the environmental impact can also be found in Chapter 8: Measuring and communicating impact*, or in* Lambert Academic Publishing's Sustainable systems for cold storage in the tropical climate. *Insights from cold chains in Southeast Asia are often transferable to the SWIO region.*

Understand what warranties cover, and for how long. A warranty is a formal guarantee provided by a manufacturer that a product will perform as expected for a given time period. If it does not, either a replacement or maintenance support will be provided. Understanding the warranty terms of cold chain equipment is essential for developers and investors, especially those that are operating in regions that have severe weather impacts on technologies. Strong warranties reduce long-term risk, protect against premature failures and ensure that developers have access to reliable servicing, spare parts and technical assistance. A well-structured warranty should clearly define what is covered (e.g., labour, parts, transport, replacement of faulty components, or the entire system as a whole) and for how long. It should also specify response times, which are critical given the risk of downtimes, and exclusions (e.g., if handled by untrained personnel, or non-certified parts are used, etc.).

Action: Carefully review the warranty and ensure that all key risks are reasonably covered. Technical opinions from engineers or lawyers can also be beneficial.

Confirm the specifics around installation, warranty and after-sales servicing. Ensuring long-term reliability and sustainability requires clarity on installation and commissioning capabilities of the supplier, as well as provision of spare parts and maintenance services. Poor installation, inability to obtain spare parts and/or lack of sufficient maintenance support often led to failure of cold chain projects and stranded assets.[68]

Action*:* Subject to technology, request a detailed installation plan from the supplier, covering steps from site foundation, energy installation and wiring to ventilation, water

65 FAO. (2025). Solar energy and the cold chain: A guide for small-scale fisheries interventions.

66 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

67 FAO. (1999). Fishery harbour manual on the prevention of pollution.

68 Efficiency for Access, Practitioners guide

installation and drainage set-up. This should all be monitored and reviewed during commissioning. Make a list of specified minimum spare parts inventory for the supplier to provide for ease of access. Additionally, include service level agreements (SLAs) in the supply contract or with a service provider for consistent maintenance of the equipment.

For more information on installation, commissioning and maintenance of cold chain technologies, please see Walk-in cold rooms, a practitioner's technical guide by Efficiency for Access.

Table 21 summarizes critical topics to consider in cold chain equipment procurement specifications.

Table 21: Critical topics for equipment procurement specifications

Condition	Description or Rationale	Verification Method
Performance definition	Quantified cold chain requirements such as equipment capacity, cooling output, temperature range and pull-down time	Test reports and certificates, datasheets, ISO references
Environmental suitability	Rated for tropical regions with high heat, high salinity and power availability	IP rating,[69] material specs, T-class documentation
Installation readiness	Project location and installation requirements	Installation plan, commissioning templates
Warranty & support	Ensures long-term reliability through continued maintenance	Warranty documents, SLAs, spare parts inventory
Supplier references	Confirms proven track record and credibility of suppliers	Reference checks, equipment test reports, contactable clients

For a specification template, please see the Tools and Appendices *for the* Sample SWIO Cold Chain Procurement Template**.**

7.2 Selecting the appropriate procurement approach

Selecting the appropriate procurement approach is critical to securing high-quality cold chain equipment, achieving value for money, maintaining transparency and ensuring timely implementation. No single approach fits all projects, and the selected method depends on project size, equipment complexity, supplier landscape, funding source and urgency. Below is an overview of the four most common procurement approaches used in cold chain projects.

69 Ingress Protection (IP) is rate at which equipment is resistance of an enclosure against the intrusion of dust or liquids

Table 22: Overview of procurement approaches

Procurement Approach	Description	Advantages	Limitations	Best Fit For
Open tendering	This is a publicly advertised competitive process where any qualified supplier may submit a bid. It maximizes transparency and competition, making it suitable for large, donor-funded projects.	Strong competition may lead to better pricing High transparency and audit readiness Encourages a wide supplier pool	Time-consuming (evaluation, clarifications, contracting) May attract unqualified or inexperienced suppliers Requires strong technical evaluation capacity	Large cold rooms, ice plants, or multi-equipment procurements Donor or government-funded projects requiring transparency Projects where cost comparison is critical
Restricted or shortlisted tendering	Only pre-qualified or vetted suppliers are invited. This approach prioritizes quality and reliability over broad competition, making it suitable where technical performance is critical.	Higher-quality submissions Faster and more manageable evaluation Reduced risk of low-quality proposals	Smaller supplier pool Requires a pre-qualification step	Projects in remote or coastal locations where only a few suppliers can meet technical needs Limited administrative capacity, or rapid procurement needs
Direct procurement or single sourcing	Purchasing from a single supplier without competition. This should be used sparingly and only when justified by urgency or technical constraints.	Fastest method Simplifies replacement and compatibility issues Useful in urgent or operationally sensitive cases	Higher price risk Extremely low transparency Requires strong, documented justification (especially for donor projects)	Remote areas where only one supplier exists Limited administrative capacity, or rapid procurement needs Emergency equipment replacement Spare parts or components requiring strict brand compatibility
Framework agreements	Long-term agreements with one or more qualified suppliers with pre-set prices, delivery terms and specifications. Suitable for multi-site rollouts or multi-year programmes.	Saves procurement time, does not need to be repeated Enables volume pricing and standardisation Reduces administrative burden	Less flexible if new technology types are needed later Not suitable for one-off purchases	National or regional programmes upgrading multiple BMUs NGOs or cooperatives procuring similar systems over 1–3 years Projects seeking standardized equipment and predictable pricing

Find and pre-qualify potential suppliers before choosing a procurement approach. To identify potential suppliers, begin by mapping the market: compile potential suppliers, begin by mapping the market. Compile a long list of vendors that supply the selected cold chain technology through online searches, trade directories, regional cold chain market assessments and referrals from industry stakeholders. Please see the SWIO Procurement List in the Tools and Appendices for some example cold chain technology suppliers.

Action: Start by compiling a comprehensive vendor list from trade directories, market assessments, cold chain forums and peer referrals. Apply the project's technical specifications to pre-qualify suppliers to only those that offer the required technology to meet technical specifications, as well as sourcing considerations (e.g., delivery lead times and after-sales support). Once a few vendors have been shortlisted, request quotations and technical datasheets, test reports and previous project references to verify supplier capability before finalizing the procurement approach.

Validate the procurement method for quality and affordable equipment while considering project timelines and risk level. An effective procurement approach should consider technical quality of the equipment while ensuring cost-effectiveness, alignment with the project's timelines and funding requirements. Timelines should be realistic based on project scale and complexity, such as open tendering for transparency and competition, or restricted tendering for specialized technologies. The approach selected should also consider the funding source and its stipulations – for instance, donor or government funded projects may have strict procurement regulations. To ensure efficiency and quality, use clear evaluation criteria, justifying the chosen approach in relation to the project's needs and budget. Consider conducting due diligence on verifiable supplier references from tropical regional installations, evaluating warranty requirements and long-term service needs.[70]

Action: Ensure the procurement approach focuses on technical performance, project timelines and funder requirements. Incorporate equipment specifications, test reports for verification, warranty obligations and installation requirements for the suppliers to meet. Additionally, include maintenance expectations to minimize long-term operational risks. Document the rationale for using the selected approach to ensure the approach aligns with the project's requirements, budget and timelines.

Please see **Table 23** on key due diligence topics when selecting a supplier.

70 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Demonstration at a solar ice plan in Tanzania

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Kenneth Nyambo, Takaungu solar ice plant technician undertaking maintainance

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Walter Kalama, fisher and Vice Chair of Takaungu BMU sorts his harvest at the Takaungu landing site

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Table 23: Key factors to consider in selecting a supplier

Condition	Description or Rationale	Verification Method
Technical quality & performance compliance	Ensures equipment meets required cooling performance, efficiency and safety industry standards, preventing operational failure	Review test certificates, ISO compliance documents, technical datasheets
Supplier capability, reliability & tropical region experience	Confirms the supplier's ability to deliver, install and maintain equipment in high-humidity, high-salinity or remote fisheries environments	Check references, past installations, site photos and service history
After-sales service, warranty and spare parts	Minimises downtime through strong local service support, available spare parts and warranties covering compressors and controllers	Review service level agreement (SLA), warranty terms, local technician availability, spare parts inventory
Procurement transparency and evaluation rigour	Ensures fair competition and quality prioritisation through a clear evaluation matrix weighting technical quality highest	Review tender documents, scoring matrices, evaluation reports
Timelines, logistics and installation feasibility	Ensures equipment can be delivered, installed and commissioned within required schedules, avoiding delays and spoilage risks	Supplier delivery plan, shipping documents, installation schedule, commissioning plan

Discuss the installation process in detail with others to ensure smooth setup. Adhering to climate-appropriate installation guidelines is crucial and significantly improves durability and reduces lifecycle costs. Cold rooms, for example, require strong foundations and adequate insulation across the walls, ceiling and panelling to minimize cold air leakage. Evidence from sustainable cold chain pilots such as the R290 cold stores, which is a climate-friendly cold store equipped with energy-efficient refrigerant and low GWP foam blowers in Kenya, shows that correct foundations, insulation, refrigerant choice and solar or electrical configuration reduce long-term failure rates.[71]

Action: Different technologies come with different complexities. However, given the criticality of proper installation, experts (usually specialized engineers) should be involved throughout the process. Spend time with the engineers and monitor the installation to build a better understanding of the system. After installation, thoroughly inspect the system (e.g., electrical connections and wiring, airflow channels, etc.) and document commissioning tests and validate performance before the installation is marked as complete.

7.3 Strategies for long-term maintenance

Cold chain systems need to be supported by reliable, local service networks with access to spare parts and trained operators who can maintain performance, even in demanding conditions. Investments should not be made unless there are long-term maintenance plans and service providers available, or commercial partners committed to building the capacity of local service providers. Table 24 summarizes the critical conditions to consider for long-term maintenance.

71 Green Cooling Initiative. (n.d.). Lessons from Lake Victoria.

Table 24: **Critical conditions for long-term cold chain operations**

Condition	Description or Rationale	Key Performance Indicator (KPI)
Skilled, certified technicians	Engage certified providers, formalize SLA, maintain contact, training and refresher courses	Maintenance and quick repairs are critical for reliability, especially under demanding conditions
Local service networks	Reduces downtime by ensuring technicians and service providers can respond quickly	Service contracts at least 5-10 years, technician directory, service level agreements, maintenance logs
Continuous training	Ensures operators understand daily monitoring, basic maintenance and troubleshooting	Training logs, certificates, refresher session records, SOP manuals
Spare-parts availability	Ensures rapid replacement of components that commonly fail in LMIC fisheries	Spare parts inventory checklist, supplier disclosure forms, procurement records
Long-term maintenance & replacement budgeting	Estimate cost cycles and contingencies, budget annually for maintenance & parts	Maintenance schedule, quarterly inspection reports

Kenneth Nyambu(left) lead technician at the Takaungu Solar Ice plant and attendant Said Mkali

Ensure the standard operating procedures (SOPs) account for local environmental conditions. SOPs refer to documented step-by-step instructions that describe how to perform operational tasks in a consistent manner, to ensure that processes are carried out correctly, uniformly and in compliance with regulations and set standards (**Table 25**).

Standard operating procedures for cold chain maintenance should always consider environmental conditions, technician availability, hygiene of the cold rooms and end-to-end supply chains. Designing maintenance plans tailored to the local context (e.g., climate patterns, access to power, technicians, etc.) will help reduce delays, lower servicing costs and facilitate the proper stocking of spare parts at strategic hubs.[72]

Action: Create SOPs that are practical, region-appropriate and responsive to actual conditions across the SWIO region. SOPs can include when cleaning of materials such as panels will be conducted, inspection and frequency thereof to ensure proper functioning, and what necessary skills and knowledge operators must have. Ideally, it should also list which technicians can be reached to help with repairs and maintenance, and where parts can be sourced.

For considerations on what to include when developing an SOP, refer to Greenstream Publishing's Solar Electricity Handbook. *Though focusing on solar PVs, it provides good general insights into what goes into a strong maintenance plan.*

72 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Table 25: Standard SOP structure

Section	What to include	Purpose
Title and purpose	Clear title, e.g. SOP for maintenance of cold chain equipment Concise statement on what the SOP aims to achieve, (e.g., "This SOP provides guidelines for how to properly maintain this equipment.")	Ensures the user understands the objective and relevance of the SOP immediately
Application	Who the SOP applies to (roles/department) Where it applies (site, part of the cold chain or the entire system)	Defines boundaries so users know when and by whom the SOP must be followed
Definition and key terms	Technical terms Abbreviations Process-specific jargon	Ensures clarity and prevents misinterpretation, particularly for new or rotating staff
Roles and responsibilities	List of responsible parties (e.g., technician, engineer) Specific duties required for compliance	Establishes accountability and clarity in execution
Required materials and equipment	Tools, machines, PPE, materials for cleaning, etc. Calibration or what is needed to prepare before conducting in this case maintenance	Ensures users are fully prepared before beginning the procedure, reducing errors and downtime
Step-by-step procedures	Sequential numbered steps Clear and actionable instructions (e.g., do X, check Y and record Z)	Provides operational consistency and allows replication of the task at the same quality level every time
Documentation and records	Logs, checklists, forms to be completed Where records are stored	Supports audits, compliance and process improvement
Revision history (optional but recommended)	Version number if ever the SOP is updated Date updated Description of changes made	Maintains document control and ensures staff always use the most up-to-date procedure

Formalize partnerships with qualified, available technicians. Many coastal communities have limited or no experience with cooling technologies; therefore, training of key operating and maintenance skills will be essential. Experienced technicians should ideally be used for recurring checks and maintenance, and equipment suppliers should be able to provide a list of certified or recommended technicians (**Table 26**).

Action: Before installation, developers should map the roles required for maintenance, which will largely depend on the complexity of the cold chain operations. These should then be incorporated into the SOPs. Besides identifying and aligning with reliable servicing partners, further opportunities may include partnering with local technical schools for readily available technicians close to cold room sites. Partnerships with NGOs or associations (e.g., GCCA Africa) can also strengthen regional expertise and support networks.

Table 26: **Key roles required for maintenance of equipment**

Role	Key responsibilities
Technicians	Conduct frequent inspections Clean solar panels and other components Troubleshoot defects (inverter faults, electrical issues) Replace/upgrade components as technology evolves
Operators	Monitor temperatures and system performance Perform basic checks and cleaning Maintain logbooks Escalate complex problems to technicians

Train the team on required in-house maintenance. Developing SOPs around in-house maintenance can help all responsible parties clearly understand their roles. Having this documented, along with refresher courses, will help with knowledge transfer in case of staff member turnover.

Action: Developers should ensure that cold chain technologies can operate reliably over time, ideally by:

- Developing and standardizing a full manual aligned with the maintenance SOP, including troubleshooting guides, safety steps, maintenance checklists and clear instructions for daily tasks.
- Training staff through practical, hands-on sessions covering loading/unloading practices, daily monitoring, cleaning routines and basic troubleshooting.
- Embedding a handover protocol to ensure continuity during staff transitions, preventing loss of knowledge.
- Establishing mandatory daily logbooks and record-keeping systems to track temperatures, maintenance performed, spare parts replaced and incidents, ensuring institutional memory and warranty compliance.
- Planning and budgeting for periodic refresher trainings, including pre-season sessions before high-demand fishing periods.

Formalize partnerships to access spare parts. Reliable access to spare parts is critical to minimize downtime when equipment fails, particularly in remote SWIO communities where sourcing is challenging.

Action: Engage with local and regional service providers during the project design phase to ensure that technical support for the selected technology is accessible when needed. Establish long-term service agreements with guaranteed response times, locate spare part hubs close to major landing sites or fisheries clusters and engage with cold chain associations, such as Global Cold Chain Alliance Africa, to strengthen technical partnerships and support networks. Also, tracking spare parts consumption in maintenance logs helps to better project when spare parts might be needed. It is also important to differentiate between part types: commonly replaced items (e.g., fuses, door seals) should be sourced locally, while more expensive spare parts (e.g., compressors, inverters,) can be obtained from regional sources as needed.

Budget for replacement parts and longer-term maintenance plans to avoid stranded assets. Maintenance of cold chain systems is too often reactive rather than proactive and consistent. This is often because ongoing maintenance is not budgeted for, so projects wait until something breaks, increasing project costs. In hot and coastal regions, small faults (dust build-up, loose wiring, failing gaskets, etc.) escalate quickly into major breakdowns. maintenance, guided by monitoring data, can reduce repair costs and extend a system's life by years.[73] Also, plan for replacement part needs – for example, for off-grid and hybrid-powered cooling systems, the recurring cost of battery replacement, typically required every five years, is frequently overlooked in long-term budgeting.

Action: Estimate annual maintenance costs upfront based on maintenance schedules, spare-parts consumption rates, technician labour, replacement intervals and contingencies (e.g., power surges, environmental stress). Data to determine such costs can be obtained from suppliers or comparable cold chain investments.

Integrate warranties into the maintenance strategy. Warranties provide additional coverage but often have key exclusions; therefore, when developing the maintenance strategy, it is critical to have the resources in place to proactively plan for issues that will not be covered. Additionally, there are always conditions for the warranty to be eligible (e.g. proper maintenance and using certified technicians). Therefore, these considerations should be embedded into the maintenance plan and report defects early. This can reduce immediate maintenance costs but may require structured preventive maintenance to meet warranty conditions, such as regular cleaning, inspections and calibration. In the SWIO region, most components are imported, and warranties may specify that only certified parts can be used. Therefore, planning, maintaining relationships with authorized service providers, ensuring spare parts are accessible and avoiding unapproved repairs is critical.

Action: Ensure the key terms and conditions that are included under warranty are understood, including warranty obligations of the supplier in case of system failure shortly after installation. Monitor performance and report defects early. Early defect reporting prevents minor issues from becoming unrepairable to ensure warranty validity. Additionally, warranty compliance should be part of the onboarding for both technicians and operators.

73 Efficiency for Access. (2023). Walk-in cold rooms: A practitioner's technical guide.

Plan for intensive oversight during the initial ramp-up period. Community- and BMU-led facilities frequently fail not from poor design but from the absence of structured support once commissioning ends. Donor-financed projects carry the greatest risk, as funding cycles routinely conclude at the point of opening, withdrawing backstopping support when operational competence is still consolidating. The project developer must therefore budget for a defined post-commissioning oversight phase, typically three to six months. During this time, a designated technical partner such as a government authority or NGO conducts routine check-ins, resolves emerging operational problems, and reinforces capacity built during pre-opening training. Oversight should be structured against measurable milestones and stepped down only once the facility demonstrates sustained operational competence.

Action: Identify and formalize a backstopping partner before commissioning, defining their scope, visit frequency and exit criteria in writing. Structure oversight against clear milestones, including temperature log compliance, maintenance routine adherence and revenue collection. Budget for this phase explicitly within the project financing plan and ensure the designated partner has the technical competence to troubleshoot both equipment and governance issues as they arise.

An aerial view of Takaungu Solar Ice plant, in Kilifi County, Kenya

CHAPTER 8: MEASURING AND COMMUNICATING IMPACT

As a final step, it is imperative to plan for how to measure and communicate the impact of the project. Effective impact measurement translates technical performance data such as energy use and waste reduction, or the uplift in fishers' income, into compelling evidence of economic, social and environmental benefits. This chapter will provide practical guidance, including key indicators and actionable steps to equip developers with a practical approach to measuring and communicating the broader value of cold chain projects.

8.1 Design of MEL framework

A monitoring, evaluation and learning (MEL) framework is used to track performance, measure impact, and inform timely decision-making on projects. Measurable indicators are used to validate a project's impact potential and produce reliable evidence needed for stakeholder reporting and other ESG disclosures.

Measure consistent and accurate impact data. The MEL framework first defines the theory of change, which explains how activities lead to specific outputs, and ultimately outcomes, like reduced post-harvest losses, enhanced fishery livelihoods and environmental sustainability, among other. To measure the progress against the objectives defined in the theory of change, the MEL framework further specifies what data to collect, who collects it, what tools are used, and cadence, covering – as the name gives away – monitoring, evaluation and learning.[74]

74 FAO. (2023). Monitoring, evaluation and learning framework.

Monitoring involves regular data collection and analysis to check whether interventions are on track. Clear indicators are required to measure outputs, outcomes and impact. Baseline measurements are needed to compare changes over time, with subsequent data collection being performed at a pre-defined frequency (e.g., daily temperature logs, seasonal catch data, etc.).

Evaluation examines how well an intervention is performing against its objectives, assessing changes attributable to the project, and assessing relevance and effectiveness of data collection methods.

Learning involves regular reflection to ensure that evidence and results obtained are used to continuously refine project implementation and create market intelligence to inform future efforts and investments.

Table 27 outlines some key terms used in a MEL framework. They follow a logical progression from the work being done (activities) to the ultimate long-term changes achieved (impacts).

Assess which key indicators should be included in the MEL Framework. The MEL framework usually translates the theory of change into a "results framework" that quantifies both outputs and outcomes. It should balance economic, social and environmental performance, selecting indicators that clearly show whether objectives are being met. Choosing the right indicators from the beginning is key – without them, one risks missing critical progress, overlooking emerging risks and losing the ability to adaptively manage the project. In the SWIO region, where coastal livelihoods, marine ecosystems and cold chain gaps are tightly interlinked, strong key performance indications (KPIs) help ensure the interventions deliver measurable, inclusive and environmentally sound results.

Table 27: Key terms used in a MEL framework

Term	Definition	Example
Activity	Specific actions or tasks implemented to deliver the project	Installing ice plants Training fishers
Outputs	Direct, tangible products or services resulting from the activities	Number of units built Number of people trained
Outcomes	Short- to medium-term changes in behaviour, practices, or performance that result from the outputs	Reduced spoilage/ post-harvest loss Improved handling
Impacts	Long-term changes in the system, livelihoods, or environment driven by sustained outcomes	Higher incomes Stronger value chain efficiency
Analysis of unintended and intended results	Positive or negative changes that occur but were not planned or anticipated	Increased product quality Higher operation costs

A woman sorts through fish for selling. Mafia Island, Tanzania.

Assess which key indicators should be included in the MEL Framework. The MEL framework usually translates the theory of change into a "results framework" that quantifies both outputs and outcomes. It should balance economic, social and environmental performance, selecting indicators that clearly show whether objectives are being met. Choosing the right indicators from the beginning is key – without them, one risks missing critical progress, overlooking emerging risks and losing the ability to adaptively manage the project. In the SWIO region, where coastal livelihoods, marine ecosystems and cold chain gaps are tightly interlinked, strong key performance indications (KPIs) help ensure the interventions deliver measurable, inclusive and environmentally sound results.

Action: Establish the KPIs applicable to the project to measure economic, social, and environmental impact. KPIs can be identified by defining and reviewing the projects' objectives, consulting sector benchmarks (e.g., Global reporting initiative standards), and engaging with stakeholders to define priority outcomes. For new sites, baseline indicators can be established through quick assessments, secondary data or short pre-implementation surveys. For instance, speak with fishers to estimate their losses from the previous high season to establish a reasonable, retrospective baseline. The accuracy of baseline indicators is critical to measuring the impact achieved. KPIs must ideally be SMART (specific, measurable, achievable, relevant, time-bound).

For indicators to be included in the MEL framework, refer to established tools such as the FAO's Sustainability indicators and Fishery performance indicators (FPI)*, which provide proven frameworks for fisheries and cold chain projects. Note that even foreign studies can provide helpful direction in the SWIO context.*

Determine which standardized reporting frameworks to be aware of when developing MEL frameworks. Project developers seeking to disclose environmental impact should ideally adopt standardized, publicly available reporting frameworks and or metrics.

Action: In some regions, it is potentially mandatory, to make disclosures on sustainability performance, often requiring analysis of "double materiality", which refers to the impact of sustainability issues on the business and the businesses' impact on people and the environment. Two frameworks to be used include:

- **Greenhouse Gas (GHG) Protocol:** This is the most widely used environmental accounting standard, issued by the World Business Council for Sustainable Development (WBCSD) and the World Resource Institute. It is essential for defining and calculating Scope 1 emissions (direct emissions, like refrigerant leaks), Scope 2 (purchased electricity) and Scope 3 (value chain emissions). For more details on the GHG protocol, please see more details on the Greenhouse Gas Protocol website.
- **Global Reporting Initiative (GRI)**: The most widely used global standards for sustainability reporting are defined by the GRI, which help organizations determine their material topics and report on economic, environmental and social impacts to a broad stakeholder base.

For more information on what to include when developing a MEL framework and template, please refer to FAO's Monitoring, evaluation and learning framework handbook.

8.2 Operational record-keeping of inputs and outputs

Routine operational record-keeping provides the foundation for all downstream impact monitoring and financial management. The project developer should establish disciplined systems for recording daily inputs and outputs. These records enable day-to-day operational decision-making and supply the raw data that underpin outcome and impact analysis.

Table 28: **Operational record-keeping metrics**

Key indicator	Rationale	Recommended action
Reduced post-harvest fish loss	Provides strong rationale economically for cold chain investment and demonstrates efficiency and value retention	Establish a baseline (% lost pre-project), then measure % lost post-installation
Increased fisher incomes	Higher income translates into improved livelihoods and indicates either increased volumes, higher quality, and/or improved storage conditions	Track the average revenue and or profits of a sample of beneficiaries at baseline and every 6–12 months; use simple mobile surveys
Volumes and value of fish handled	Shows improved throughput volumes and values, as indication of how cold storage expands trade	Record daily throughput logs; record sale prices at landing sites; monitor periodic average volumes and price points
Cost/kg of fish stored **Cost/kg of ice produced** **Quantity of ice produced/ice sold**	Cost efficiency will determine long-term sustainability Ice produced tracks uptake in cooling capacity and, subject to usage, good handling practices	Track energy use and related cost savings, plus maintenance costs; measure economies of scale, and ice sales volume uplift

Action: Track data consistently and accurately by implementing dedicated monitoring processes and utilizing systematic methods for data collection and validation. Where digital solutions are not available, use simple paper logbooks for weekly data collection (e.g., date, species, kilograms landed, temperature at arrival, amount of ice used, etc.). Then, take pictures or digitize the information, in an Excel spreadsheet or other system. Low-bandwidth mobile data collection tools, such as the Kobo Toolbox, can also be used. Assign data collectors, define frequency of collecting data, and develop and use standard templates. Most importantly, appreciate the value of data and use it to conduct periodic evaluations and generate valuable learnings.

8.3 Outcome and impact monitoring and analysis

Outcome and impact indicators measure the changes that the cold chain project delivers beyond its operational performance. The MEL framework will track economic, social and environmental impacts to demonstrate the project's value to stakeholders and to inform future investment decisions.

Table 29 gives examples of potential economic outcome indicators. **Table 30** provides examples of social impact indicators.

Additionally, environmental sustainability in a cold chain project assessment must be thoroughly measured, managed and reported using credible methodologies to quantify environmental impacts, meet regulatory demands and demonstrate holistic value to stakeholders. Because cold chain systems are both energy intensive and refrigerant dependent, a project assessment should explicitly measure key performance indicators such as the ones listed below. These metrics go beyond immediate project success to measure the long-term impact on global warming, energy consumption and the health of the marine ecosystem, emphasizing the use of low-global warming potential (GWP) refrigerants.

Table 29: Economic outcome indicators

Key indicator	Rationale	Recommended method
Reduced post-harvest fish loss	Provides strong rationale economically for cold chain investment, demonstrates efficiency and value retention	Establish a baseline (% lost pre-project) and then measure % lost post-installation
Increased fisher incomes	Higher income translates into improved livelihoods, indicates either increased volumes, higher quality, and/or improved storage conditions	Track the average revenue and or profits of a sample of beneficiaries at baseline and every 6–12 months, use simple mobile surveys

Table 30: Social impact indicators

Key indicator	Rationale	Recommended method
Jobs created	Cold chains often create jobs for operators, technicians and logistics and others within the fishery value chain	Track employment numbers, gender and age disaggregation.
Women and youth reached	Gender-responsive interventions ensure equitable distribution of benefits	Include gender/youth KPIs. Train women and youth as operators, traders, or managers
Strengthened local governance	Sustainability depends on strong community institutions – ultimately, operational and financial success reflect the strength of governance	Document training, co-management structures and community agreements using tools like Elinor
Availability and improvements in cold chain services	Cold storage enhances food security	Monitor reduction in seasonal fluctuation of fish availability and reduction in the seasonal price volatility of local fish retail prices
Improved nutrition and health	Access to preserved, high-quality and safe food directly improves dietary diversity and intake of essential micronutrients and protein, particularly for vulnerable populations	Monitor the prevalence of anaemia/malnutrition among target groups

Table 31: Environmental impact indicators

Key indicator	Rationale	Recommended method
Global warming potential (GWP) of the refrigerants used	Refrigerant leakage during operations contributes to greenhouse gas emissions. The climate impact depends on both the GWP rating of the refrigerant and the volume of leakage; refrigerant contained within the system produces no direct climate impact	Record the refrigerant type, GWP rating and charge volume from the equipment supplier. Monitor equipment for refrigerant leaks by tracking refilling rates. Calculate annual emissions by multiplying refrigerant losses by the CO_2-equivalent of the refrigerant.[75] The State of World Fisheries and Aquaculture (SOFIA) consistently recommends natural refrigerants (NH_3, CO_2, R-290) for fish processing and storage as they minimize climate impacts.[76]
Energy use efficiency	Efficiency is a core sustainability metric and ultimately will influence operational expenses	Record energy inputs (kWh of electricity or litres of diesel) per unit of product.
Carbon footprint of the cold chain operation	Measuring carbon footprint measuring is now required by most funders for climate alignment	Compute greenhouse gas emissions (CO_2-equivalents) of operations, measure electricity use, refrigerant leakage and diesel use. [77]
Wastewater discharge	Cold chain operations generate wastewater from ice production, fish processing and equipment cleaning that may contain organic matter and chemical residues. Unmanaged discharge degrades local water quality and may violate environmental regulations	Measure discharge volume and quality (pH, biological oxygen demand) against local regulatory thresholds. Implement treatment or containment where discharge exceeds permissible levels.[78]
Fish stock health	Cold chain capacity can unintentionally increase pressure on fish stocks If designed well, cold chains can also incentivize improved governance and data collection, foundational to successful fisheries management	Monitor fisheries governance indicators like compliance, co-management data, catch monitoring (species specific catch per unit effort and length frequency as a minimum). [79]
Ecosystems protected	Cold chain capacity, if designed well, can create the incentive to improve the overall management of coastal ecosystems	Monitor the health of ecosystems, such as coral reef health in coral reef-dependent fisheries or mangrove health in mangrove-dependent or associated fisheries. Record evidence of restoration efforts or closed areas caused by incentives provided by the cold chain project
Post-harvest loss (PHL) rate	Fish lost to spoilage represents wasted fishing effort and its associated environmental costs, including vessel fuel consumption, gear use and ice or refrigerant energy demand. Reducing PHL improves the environmental efficiency of the fishery – more food reaches consumers per unit of ecological and carbon cost incurred during harvest.	Measure PHL by weight at each value chain node before and after cold chain intervention to establish a baseline and track improvement. Express results as the proportion of landed catch lost pre-consumption. Use avoided loss figures to estimate the reduction in fishing effort and associated emissions required to replace spoiled product.[80]

75 GOV.UK. (2024). Calculate the carbon dioxide equivalent quantity of an F gas.
76 IIAR. (2019). Natural refrigerants for a sustainable
77 UNDP. (2022). Guidance note: Assessing greenhouse gas emissions from refrigerants use in UNDP operations.
78 FAO. (1996). Wastewater treatment in the fishery industry.
79 WWF. (n.d.). Environmental and social safeguards.
80 Gustavsson, J., et al. (2011). Global food losses and food waste: Extent, causes and prevention. *FAO*.

Understand why it is critical to measure global warming potential (GWP) for cold chain projects. Refrigeration systems are responsible for greenhouse gases (GHG) emissions that intensify global warming; specifically, this includes direct emissions from refrigerants and indirect emissions from energy use.[81]

Measuring greenhouse gases helps measure the global warming potential (GWP), which helps developers and investors track and hopefully minimize the cold chain's overall climate impact. Ensuring the project is compliant with evolving international and national regulations protects the investment by avoiding the use of equipment that will soon be obsolete or banned. By calculating emissions from both direct and indirect sources, developers can determine which factor is the largest contributor to the project's total emissions allowing for prioritization of mitigation efforts. [82]

Action: Integrate efforts to minimize global warming potential (GWP), such as mitigating direct emissions from refrigerants and the significant indirect emissions from energy consumption. The following three actions form the foundation of a climate-responsible cold chain strategy:

1. Calculate and evaluate life cycle climate performance (LCCP), to move beyond simple energy efficiency metrics and utilize the LCCP methodology for all refrigeration equipment selection. The LCCP measures the environmental impact of a system over its entire life, including direct emissions from refrigerant leaks and indirect emissions from energy consumption. *For more details on how to calculate LCCP, refer to* IIR's Guideline for life cycle climate performance and calculation tool.
2. From a climate perspective, prioritize naturally occurring substances (e.g., CO_2 or hydrocarbons) that possess ultra-low or near-zero GWP to comply with global mandates like the Kigali Amendment.
3. Establish rigorous protocols for regular equipment maintenance, servicing and the responsible recovery and recycling of refrigerants at the equipment's end-of-life.

Ensure projects integrate environmental sustainability into daily operations. Environmental accounting should not be an afterthought but embedded systematically in daily operations, with Scope 1, 2 and 3 emissions monitored and linked to operational decisions. This involves adopting a structured, phased approach, such as the Environmental Management Accounting (EMA) Procedures and Principles.[83]

Action: Establish robust internal systems for data capture, calculation and auditing. Embed sustainability into daily operations, ensure teams have clear processes and defined responsibilities. The steps below outline how to systematize data capture and strengthen accountability:

- Implement standard operating procedures (SOPs) for collecting energy and refrigerant usage data.
- Train all team members so they understand their role in capturing emissions-related data and that accountability is built into operational workflows.
- Adopt a formal phased reporting cycle to guide sustainability integration.

The transition to a sustainable cold chain is not merely an environmental obligation but a strategic necessity for long-term project viability, operational resilience and financial competitiveness.

For guidance on environmental and social safeguards, including whistle-blower mechanisms, please refer to the WWF Environmental and Social Safeguard Framework.

81 Emissis. (2024). The impact of refrigeration on global warming.

82 World Resources Institute and World Business Council for Sustainable Development. (2011). Greenhouse gas protocol: Corporate value chain (Scope 3) accounting and reporting standard.

83 United Nations Division for Sustainable Development. (2001). Environmental management accounting procedures and principles.

8.4 Communicating impact to stakeholders

The final stage of the MEL process involves translating collected data into compelling information and learnings for decision-makers and stakeholders (**Table 32**). This evidence of the value of the project will inform future efforts.

Define how results can best be communicated to funders and communities. Funders, especially those focused on climate and development, require quantifiable evidence of impact and or return on investment. Clear communication combines numbers, visuals and narratives. Funders value dashboards and quantified outcomes, while communities typically value practical improvements and testimonies.

Action: Align with key stakeholders on how results should be communicated and presented, as well as frequency of reporting. An example may be creating a quarterly one-page "Impact Snapshot" with KPIs and success stories that can be shared within networks, to funders or on company websites. This can be supplemented with more extensive reporting either every six or 12 months.

Example: *InspiraFarms provides a useful example of how cold chain developers can communicate impact effectively. The company regularly produces reports and* learning briefs *with other development partners that distill lessons from data collection, system deployment and customer adoption. They also maintain a dedicated* impact section on their website, *where they highlight key outcomes linked to food-loss reduction, energy efficiency and climate benefits. This approach demonstrates how transparent reporting can build funder confidence, support stakeholder engagement and showcase the broader value of sustainable cold chain solutions.*

Table 32: Critical conditions for demonstrating project value to stakeholders

Condition	Description or Rationale	Verification Method
Clear, Quantifiable Results	Funders and stakeholders require measurable evidence of project impact, including economic, social and environmental benefits.	Ensure monitoring, evaluation and learning framework includes well-defined KPIs, baseline and target data and standardized reporting templates. Prepare dashboards and visual summaries
Tailored Communication	Audiences require different formats: funders need numbers and ROI analysis; communities need practical outcomes and success stories.	Use multi-format reporting: dashboards, infographics, short narrative reports and community testimonials. Conduct stakeholder engagement sessions to validate messages.
Stacked Value Demonstration	Evidence that the project delivers combined economic, social and environmental benefits strengthens investability and stakeholder confidence.	Present integrated metrics in reports showing reduced losses, income improvements, employment, environmental performance and community benefits.
Transparency & Accountability	Trust is built when results are verifiable and linked to robust monitoring.	Conduct independent audits or third-party verification of MEL data. Include publicly accessible summaries or dashboards.