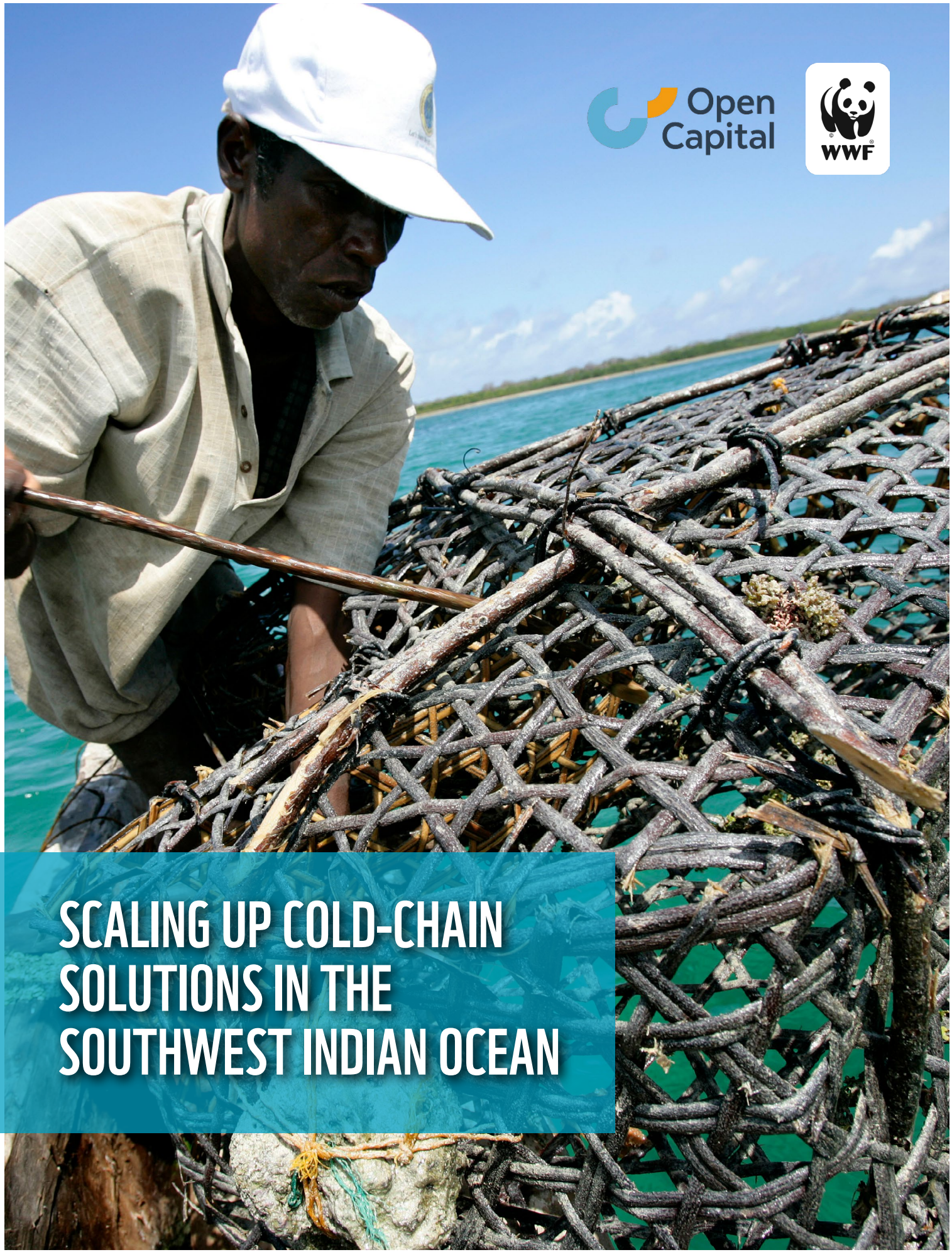

SCALING UP COLD-CHAIN SOLUTIONS IN THE SOUTHWEST INDIAN OCEAN

ACKNOWLEDGEMENTS

WWF thanks Open Capital Associates for their hard work and dedication to the project. WWF thanks Richard Scotney, Samantha Petersen, and Pete Pearson for their guidance and leadership. WWF Switzerland contributed to the project through Food Practice Innovation Funds.

CONTENTS

▲ *WWF Learning exchange with Beach Management Unit leadership in Kwale Country, Kenya.*

OVERVIEW

WWF has long been committed to investing in small-scale fisheries and cold-chain interventions with the aim of building resilience, protecting livelihoods, and reducing environmental stress in fishing communities. Cold-chain solutions are part of a systems-based approach to transforming entire supply chains to make them more resilient and sustainable. So they must be delivered alongside strong governance mechanisms to ensure sustainable fisheries practices.

In 2022, WWF began a cross-functional exploration of cold-chain interventions within the Southwest Indian Ocean (SWIO) region. Organized by WWF's Climate, Oceans, and Food practices, it focused on an integrated approach to fisheries management and came up with the following key points:

- Ocean and freshwater fisheries around the world are near capacity or have already been overexploited due to unsustainable harvesting, growing demand, and lack of sustainable fisheries management.
- There is significant post-harvest food loss (PHFL) at every stage of fisheries value chains due to insufficient cold-chain infrastructure, such as freezers, ice machines, cooler boxes, and cold rooms, as well as limited market access and transparent information flows.
- While cold chains help reduce food loss, they also create a larger emissions footprint. As such, climate-smart interventions are needed to ensure that the interventions' benefits are not overshadowed by increased carbon footprint.
- The provision of cold-chain infrastructure can incentivize more fishing, which could exacerbate the overexploitation of fisheries, with long-term consequences for food security, livelihoods, and ocean ecosystems. It is essential that strong fisheries governance and data transparency be established together with the implementation of cold-chain solutions.

WHY COLD CHAINS MATTER

Today, 811 million people suffer from hunger and 3 billion cannot afford a healthy diet. And food that could feed around 1 billion people is currently being lost. The lack of effective refrigeration is a leading cause of this problem. In 2017, it resulted in the loss of 12% of global food production.[1] Moreover, cold-chain technologies and food loss and waste due to lack of refrigeration are responsible for 4% of global greenhouse gas emissions. Specifically, cold chains are critical for the following reasons:

- **Protection of Seafood Quality.** Cold chains are integral to preserving the quality, value, and profitability of fish caught by fisherfolk. Blue foods like fish and shellfish are highly perishable and can rapidly deteriorate unless they are kept at the right temperature. Cold storage and transportation prevent the growth of harmful bacteria and slow down enzymatic reactions that lead to increased levels of histamine, which pose a health risk to consumers.
- **Market Access.** Cold-chain infrastructure enables fishers and seafood processors to store and transport their catch for longer periods, reducing the need for immediate sales and allowing for distribution to distant markets. This means that they can reach consumers in urban areas or even export their products, potentially fetching higher prices.

1 UNEP and FAO. 2022. Sustainable food cold chains: Opportunities, challenges and the way forward. Nairobi, UNEP and Rome, FAO.


© WWF-US / JAMES MORGAN

- **Compliance with Quality Standards.** Many countries and international organizations have strict quality and safety standards for seafood products. Maintaining cold chains is often a requirement to meet these standards, which ensure that seafood is of high quality and safe for consumption.
- **Economic Benefits.** A well-established cold chain can benefit not only individual fishers but also the entire seafood industry in a region. It can create employment opportunities in processing, transportation, and retail, contributing to the local and regional economy.
- **Reduction of food waste and environmental impact.** Without a cold chain, a significant portion of the catch may go to waste due to spoilage. This is a financial loss for fishers and contributes to food insecurity and the depletion of fishery resources. At the same time, the provision of a cold chain without effective fisheries governance can inadvertently incentivize further exploitation of fisheries resources.
- **Food Security.** A robust cold chain can contribute to food security by ensuring a consistent supply of seafood products throughout the year. This is especially important in regions where seafood is the primary source of protein and nutrition.

SCOPE AND RESULTS OF RESEARCH

In 2023, WWF and Open Capital Advisors (OCA) conducted research on cold-chain interventions to determine the best opportunities for scaling solutions across the SWIO region and globally. OCA analyzed five WWF pilot projects and five industry-led projects on cold-chain interventions to understand the business model, partnership structure, scalability, and impact of successful cold-chain solutions that would minimize investment risk and provide a meaningful return. WWF's country leads and public- and private-sector stakeholders in Kenya, Tanzania, Mozambique, Madagascar, and South Africa participated in the research.

1 EVIDENCE OF IMPACT

Cold storage solutions lead to reduced post-harvest food loss, environmental benefits, and more consistent and increased incomes. While they create impacts in the wider community, sustainable fishing practices must be enforced.

Environmental Impact Goals

- Reduction of PHFL and wastage of food throughout supply chains, as cold-chain solutions ensure that fish is kept fresh in storage and during transportation. In one WWF-led project on the Kenyan coast, post-harvest losses were reduced from 30% to almost zero.
- Reduction of greenhouse gas emissions and other local pollutants into the environment by using clean energy technologies. WWF has taken advantage of refrigerators that use refrigerants with low global warming potential. It has also replaced diesel-powered refrigeration units with solar-powered ones in some projects.

Fisherman Abudi, 16 (right) and a fisherman for 7 years, onboard the boat Nusra waits for his fellow crew members to arrive before going out fishing. Lamu, Kenya.

Livelihood Impact Goals

- Higher income for fishers by increasing the volume of unspoiled fish and their prices and increasing access to larger markets. In a pilot project run by the International Fund for Agricultural Development (IFAD) and SunDanzer, fishers' profits increased by $300 in the first four months, thanks to the introduction of solar-powered freezers.
- Employment generation for the wider community, including jobs to service and maintain the technology and project bookkeeping.
- Diversified revenue streams. If the fishing community owns and maintains the machinery, it can use it for other purposes, including providing ice to restaurants and bars. In one project in Kenya, for example, the local entrepreneur shared the revenue from the ice machine with the government's Beach Management Unit (BMU).
- Reduced input costs as a result of clean-energy solutions, which can boost income. This is particularly the case in certain areas, such as rural Madagascar, where current cooling options rely on diesel generation for power.

Negative Impact Considerations

The tradeoffs that cold-chain interventions could bring must be addressed to mitigate negative impacts.

- Cold-chain solutions can affect the wider community and incentivize more fishing efforts, especially with the potential for higher income and flexible hours that are no longer dictated by the timing and presence of fish dealers at the landing site. So it is important to take a holistic approach and enforce sustainable fisheries practices. For example, licensing fishers and fish dealers and conducting sea and beach-based patrols can help prevent overfishing and build partnerships with businesses to promote conservation.
- Introduction of cold chains can adversely affect players in other parts of supply chains. For example, supplying only fish dealers with cold-storage solutions can increase their pricing power over fishers who also need access to ice and refrigerated trucks. Direct-to-consumer models can increase fishers' income and allow for consistent demand and pricing.

2 MAJOR TECHNOLOGY TYPES

- **Cooler boxes** can be used to keep the catch fresh at sea and during transportation across the supply chain, including landing sites, transportation, retail, and processing. Cooler boxes can be of various sizes and are used in conjunction with ice-making machines. However, they offer limited storage space, and ice could also melt, posing a contamination risk.
- **Ice flake machines** are generally located at landing sites, but ice flakes are used by fishers at sea, by fish dealers, for transportation, at processing sites, and by retailers. They are easy to operate, have diversified uses, and are useful for fish of all sizes. They can be powered by solar energy and are easy to maintain. However, small ice flake machines offer limited storage times, and large machines require significant power and water.
- **Solar-powered fridges and freezers** are suitable cooling technologies to keep products fresh with low operating costs. They can be used at landing sites collectively or bought by individuals and used for retail

Newly installed solar drying technology capable of drying both seafood and terrestrially grown agriculture products like casava.

Solar array control panel used for ice making and solar drying.

storage and processing. Freezers can be used to produce ice, and excess space can be used to store non-fish products, increasing revenue streams. However, storage capacity is limited for large catches. Using batteries can be costly, and they require proper maintenance.

- **Refrigerated trucks** are used to transport large amounts of products to markets. More sophisticated ones have temperature controls and insulated lining to maintain cold temperatures. They are a high-cost cooling technology that can greatly increase access to domestic markets and can be used as storage units at landing sites. However, poor road infrastructure—for example, roads riddled with potholes—can cause leakage of refrigerant. They are also expensive to maintain.
- **Cold storage rooms** are temperature-controlled rooms that can hold a large quantity of fish at the landing site and at processing centers and retailers. They can be powered by solar systems and customized based on the user's need to store produce. Cold storage rooms can be combined with other technologies, such as ice machines. However, they require significant amounts of energy, a vast space, and technical expertise for maintenance, and they are often too large for smallholder fishers.
- **Functional ice** is made by adding low-cost products such as vinegar or citric acid to water before it is frozen. It can slow the melting process and remove bacteria from the fish. It offers diversified uses, is easy to make, and is safe for use throughout supply chains. This technology is at an early stage of testing.

3 MAJOR CHALLENGES

- **Project design.** Challenges include lack of community buy-in, limited scalability, delays resulting from few commercial partners, and mismanagement of public programs, which could lead to commercial partners not being able to import equipment.
- **Business operations.** Challenges relate to lack of hygiene, improper handling of fish, lack of grading, limited machine operating hours, and insufficient security for the technology solutions.
- **Technical operations.** Challenges include lack of technical expertise, technology mismanagement, expensive or inaccessible spare parts, inadequate supply of water and energy, and poor placement of machinery.
- **Finance and profitability.** Challenges relate to the effect of seasonality on income, limited financial reporting and recordkeeping, inadequate consumer financing, high cost of inputs, and price volatility.

A Kenyan fisherman preparing his ice for the day after purchasing it at Safwan Ice in Malindi, Kenya. May 2023.

4 FUNDING MECHANISMS

Most cold-chain initiatives require a considerable amount of time, money, and patience. They are also capital-intensive, with long payback periods. Therefore, it is important to fund them properly. Innovative financing solutions, such as results-based financing, can be used, but they are not common in the industry yet. Most of the cold-chain solutions are funded through grants or philanthropic financing. Three main financing models are identified:

1. **Combination of grant and publicly funded projects managed by communities.** In this model, nongovernmental organizations (NGOs) or governments provide the technology, which is then managed by the community as it operates the machinery, collects revenue, and performs maintenance services. This model promotes active community involvement, generates job opportunities, and reduces dependence on partners outside the communities. However, this model is prone to mismanagement, relies on robust buy-in from the community, which is difficult to obtain, and requires the provision of financial training and continued investment.
2. **Combination of grant and publicly funded projects managed by private partners.** In this scenario, technology is funded by NGOs or governments, and a private entity provides the services for operations and maintenance and collects revenue. This model is efficient, as it allows communities to leverage business expertise. But it also requires private partners to be aligned with community goals, with a high degree of trust established between partners.
3. **Fully private model.** In this model, private entities provide, operate, and maintain the technology. Market forces ensure that cost-effective solutions are provided to the community, which makes this model sustainable with minimal training. However, this model requires upfront funding, and it is less frequently implemented or feasible among low-income fishing communities due to a lack of investment interest.

Fish on display at the Angoche fish market in Mozambique.

This report recommends the combination of grant and publicly funded projects managed by private partners as the optimal model in the SWIO region; this model would also have a profit-sharing scheme for communities and a robust service and training strategy. This model is most likely to attract investments from financial institutions as well, specifically the following:

- **Funding provided publicly or by NGOs as grants.** Many small-scale fishers do not have bank accounts and lack access to credit to invest in cold storage equipment. Public grants can lower the financial barrier to implementing cold-chain projects.

- **Service center with aggregation of services.** This model provides an "aggregated service center" for businesses and provides training for maintenance. Such centers can also help track data on fisheries to help governments establish and enforce regulations.
- **Private management.** Private ownership allows for the swift deployment of cold-chain technologies, as well as the provision of operations and management training. Additionally, many smallholder fishers do not have access to a reliable electricity supply, and implementing solar and battery technologies can help meet their need for refrigeration solutions.
- **Service and maintenance.** Private ownership models can provide better technical capacity. Private owners also have incentives to maintain equipment properly to ensure consistent revenue.
- **BMU leadership.** Governments' BMUs can align the interests of private operators and those of the community through agreements, contracts, and provisions. BMU operators can also use cold-chain solutions to collect data and strengthen sustainable fisheries management.


© WWF / RICHARD SCOTNEY

An employee packs ice from a local Kenyan ice-making business.

5 CRITERIA FOR SUCCESS

Strengthening the following can help ensure high-quality products and sustainability of interventions:

- **Viable business model.** A profitable business model needs to be suitable and sustainable for each situation, ensuring affordability for the local communities.
- **Experienced team.** Cold-chain projects need to be run, managed, and implemented by a team with the right managerial and technical skills as well as an understanding of the local community relationships.
- **Strong leadership and governance.** A robust multi-stakeholder governance structure is necessary to ensure that the project is implemented to benefit the fishing communities.
- **Uninterrupted cold chain and market linkages.** Creating an uninterrupted cold chain, including access to clean water and electricity, is essential for a profitable project.
- **Continuous community engagement.** Articulating to target communities the values and benefits that cold-chain solutions can bring will determine community buy-in and adoption.
- **Project location.** Access to credible community land ensures that cold-chain solutions can be installed without major challenges. The location's security is essential for the longevity of the project.

RECOMMENDATIONS

As part of systems-based solutions to transform an entire supply chain, governments and supply chain stakeholders must collaborate to develop national cooling action plans and back them up with concrete targets, financing, and capacity building while simultaneously establishing and enforcing regulations to protect sustainable fisheries, specifically the following:

1. **Mandate fisheries to collect and continuously share data on catch trends and fish stock health.** Providing funding to national and local governments to conduct regular fishery health assessments must be a requirement for any investment in cold chains. The introduction of improved cold chains can also serve as an incentive to collect better data.
2. **Articulate value proposition to communities and highlight the benefits of collectivization.** Ensuring buy-in and collaboration among all parties is crucial to maximizing the impact of a project on the fishing communities and the environment in the long term. Community buy-in can be difficult to obtain, and working with individual fishers can hinder scalability. It is important to build partnerships locally and with several players and enhance collaboration among private and public parties.
3. **Provide equipment and training on best hygiene practices and proper handling and grading of products.** Lack of hygiene or improper handling of fish can deteriorate the quality of produce, leading to food loss and undermining the confidence and health of consumers. It is essential to have reliable and affordable access to resources, like water and electricity, to ensure successful implementation. Use solar-powered solutions and batteries, and run projects in strategic locations.
4. **Provide expertise from the outset, and train project personnel on the proper use of technology and monitoring.** Critical training areas are operational (post-harvest fish preservation, fish inspection, hygiene, monitoring, surveillance), technical (maintenance), financial (bookkeeping and financial recording), and leadership and governance training. Spare parts and maintenance services should be available locally.
5. **Diversify uses of cold-chain solutions, adopt innovative payment models, and provide training on financial reporting and recordkeeping.** It is critical to integrate more small-business enterprises into supply chains to provide them with access to global markets and shield them from local currency fluctuation. Provide resources to help small businesses keep strong financial records, as lack of financial records inhibits the capacity to access commercial financing and limits the ability to track impact.

Fish dealers (left to right) Abdullah Skwanda, 45, Faiz Shellilah, 34, and Said Kismay, 36, cook lunch of salty fried fish on board their dhow "Arafat" moored at Kiunga village. They have been here 10 days buying fish which they store in their cold room and will return back to Lamu Island where they are based. Lamu, Kenya.

APPENDIX

SUMMARY OF WWF INTERVENTION PROJECTS

NAME AND OVERVIEW	BUSINESS MODEL	KEY IMPACTS
Finance Earth report Business case and impact of solar-powered ice flake machines in Lamu, Kenya.	**Grant-funded/publicly run model** • Grants purchase ice flake machines, which are publicly owned. • Additional grants fund training.	• Increased volume of sellable catch, reduced waste, improved food security, reduced pressure on fish stocks, and reduced reliance on traditional fossil fuel energy generation. • BMU training on post-harvest preservation and financial management/operational responsibilities multiplies impact and ensures the longevity of the project.
Kigali Cooling Evaluation report Efficiency, impact, sustainability, and adaptability of the freezer and ice flake machines in Tanzania.	**Grant-funded/publicly run model** • Grants fund purchase of cold-chain interventions. • BMU ownership and operation solutions.	• Increased and stabilized fish prices and fisher income, reduced PHFL from 30% to nearly 0%, and increased the number of traders at the landing site, which gave fishers more bargaining power. • Support and proactive participation from the local community/government increased sustainability and improved project outcomes.
DANIDA Market Development Partnerships (DMDP) Solar for Cooling Project Delivering access to freezers in Kenya's coast to increase sector development and income growth.	**Grant-funded/privately run model** • Many small-scale fishers are without bank accounts and credit to invest in cold storage equipment. Only 30% of the Kenyan population has access to reliable electricity. The Solar for Cooling Project aims to close the gap between off-grid energy and small-scale fishers' need for refrigeration solutions.	• Trained 37 county fishery officers to mentor 29 BMUs (training of trainers). • Created three linkages to larger fish markets and four to potential financing parties. • Developed six community fishery enterprise business plans. • Providing community members with technical training and empowering them to promote financial models allow for greater trust.

TABLE CONTINUES

SUMMARY OF WWF INTERVENTION PROJECTS, CONT'D

NAME AND OVERVIEW	BUSINESS MODEL	KEY IMPACTS
Pêche Côtière Durable (PCD) Project Managing shared service centers to unlock economic potential in Madagascar.	**Grant-funded/privately run model** • Grants purchase cold-chain interventions. • Privately operated service centers provide services to artisanal fishers for access fees, an example of a cooling as a service (CaaS) model.	• Increased profitability for fishers by allowing them to remove middlemen and increase prices and market access. • Allowed for the upskilling of local fishers and community members. • Training is essential to provide technical assistance. • Service centers can have high operational costs. • Financing partners may be needed to offset costs if income generation by the local community is insufficient.
Abalobi • Addressing challenges throughout the small-scale fish value chain without large CAPEX infrastructure investment. • WWF provides funding to Abalobi and also implements its technology in some of its project locations.	**Fully private model** • Abalobi is a social enterprise that assists fishing communities in South Africa in storing, marketing, and selling their catch across the entire value chain. It provides cold storage units for a fee and a technology platform for fishers to sell their catch directly to end customers.	• Direct-to-consumer model increases income and allows for consistent demand and pricing. • Allows increased traceability of catch and supply chain. • Significantly decreases PHFL and increases the quality of product. • Allows for intensive monitoring of sustainability and product quality.

SUMMARY OF NON-WWF INTERVENTION PROJECTS

NAME AND OVERVIEW	BUSINESS MODEL	KEY IMPACTS
IFAD/SunDanzer report Deployment of 50 solar freezers in Rwanda, Tanzania, and Mozambique.	**Grant-funded/mix of privately and publicly run models** Small-scale, solar-powered pay-as-you-go fridges and freezers for artisanal fisheries.	• Significant reduction in PHFL and increased profitability of fishers (by $300 in the first four months). • Pay-as-you-go CaaS is appealing, given its low upfront costs. • Services can have high operational costs. Financing partners may be needed to offset costs if income generation by the local community is insufficient.
KeepITCool (KIC) report Assessing the impact on PHFL that cold-chain technology can have on fish retailers and fishers in Kenya.	**Fully private model** • KIC has a CaaS model, which lowers cold chain barriers for small-scale fishers. • KIC handles the storage, transport, marketing, and retail of products through its online trading platform.	• 39% of fishers reported reduced wastage; 31% reported increased income. • Improved preservation of fish leads to higher product quality and higher available prices in the end market.
GIZ report Analyzing challenges and potential solutions throughout the cold chain.	**Grant-funded/mix of privately and publicly run models** Some cold storage facilities are run by private businesses, some by cooperatives.	• Significantly reduced PHFL and increased product quality. • Cooperative created well-paying jobs for the community.
InspiraFarms report Assessing the effectiveness of the distributed cold storage CaaS model in improving farmer incomes.	**Fully private model** Mobile cold storage solutions to farmers through CaaS business model.	• Increased the volume and shelf life of fresh produce, leading to lower PHFL. • Reduced logistical costs, boosting profitability margins. • Enables tapping into export markets with higher price points.
Energy4Access report Assessing various cold-chain infrastructure solutions across different value chains in Kenya.	**Grant-funded/publicly run model** Donors provide cold-chain solutions, such as solar-powered walk-in cold storage rooms, which are then transferred to farmer cooperatives.	• Use of cold-chain solutions increased net income by 30%, as PHFL was reduced. • Rental, pay-as-you-go models, and CaaS reduce the financial burden of solutions. • It is important to note that freshwater fish production is five times higher than marine fish production, suggesting an avenue for more investment in freshwater solutions.

together possible

For further information, contact:

Pete Pearson
Senior Director, Food Waste
pete.pearson@wwfus.org

WWF, Avenue du Mont-Bland, 1196 Gland, Switzerland. Tel. +41 22 364 9111. Fax. +41 22 364 0332.