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Logistical and Operational Challenges in Cold Chain Systems for Fishery Products in Developing Countries: A Literature Review

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Abstract

The delivery of fishery products must consistently maintain product quality and integrity to prevent deterioration during the post-harvest period. In developing countries, the distribution of fishery products faces challenges in the post-harvest cold chain system, ranging from infrastructure, technology, and transportation to human resources. This study aimed to identify the logistical and operational challenges in implementing cold chain systems for fishery products in developing countries. The methodology employed in this research is a literature review, with data obtained from accredited journals focused on the subject of cold chain systems. Based on the literature review, it was found that cold chain system challenges in developing countries include road infrastructure that does not connect regions, technology that does not apply to the cold chain system because of high financial requirements, transportation units that do not meet cold chain shipping standards, There is a deficiency in both infrastructure and personnel resources, contributing to an inadequate grasp of the crucial need to uphold the standard and dependability of seafood items throughout the stages following harvesting. The implications and recommendations include the need for improved infrastructure development, investment in technology, implementation of transportation units that meet cold chain standards, and enhancement of human resource quality.

Keywords: Cold Chain System, Distribution, Fisheries Logistics, Fishery Products, Logistical Challenges

1. Introduction

Across nations with varying levels of economic progress, including both wealthy and less wealthy ones, items that spoil quickly, like produce, greens, milk-based goods, seafood, and various meats, all share a common trait of not staying fresh for very long after being gathered or made. The duration that these specific items can be displayed for purchase or deemed suitable to eat is variable, relying on what the item actually is and also outside conditions. (Mercier et al., 2019). Cold chain logistics is a crucial part of the supply chain that maintains the integrity of perishable goods from their origin to the end consumer. The importance of cold chain logistics is increasing as the global demand for fresh and safe food products, such as temperature-sensitive seafood, increases (Shi et al., 2024). A temperature-regulated supply network that stretches from the initial catch to the final buyer is what constitutes a cold chain for food items that spoil easily. This incorporates processes like arranging, categorizing, cleaning, dehydrating, initi al chilling, keeping, and delivering. (Hundy, 2019; Vrat et al., 2018). Cold chain logistics are needed to connect fishermen with markets to add value to the harvest (Joshi et al., 2011).

The transportation of newly harvested goods is essential today's supply networks, maintaining and newness of items that spoil quickly, and making the delivery process as effective as possible (Defraeye et al., 2016). The fisheries and marine sector plays an important role in Indonesia's economy because of the large number of people who depend on it

(Stacey et al., 2021). Moreover, for a significant portion of the population residing in shoreline regions, working in the fishing industry represents their primary way of supporting themselves (Manurung, 2016). The substantial effect of exporting both main and supporting fisheries on local financial gains and creating various job opportunities cannot be understated (Yusuf & Tajerin, 2007). The worldwide trading of items prone to spoiling, for example, both chilled goods and prepared meals, continues to grow along with changes in people's lifestyles; therefore, perishable fishery products must maintain their quality during post-harvest activities. The distribution process is part of the post-harvest fisheries logistics activities, where distribution becomes a vulnerable activity in maintaining the quality of fishery products.

The ongoing evolution of the logistics sector has brought about the development of a vast and sophisticated supply chain system for recently caught seafood. This system incorporates a variety of steps that happen after the seafood is caught, such as packing, moving, storing, and selling. A key difficulty within this all-encompassing system is ensuring that the fresh seafood is distributed effectively without compromising its quality (Yu, 2022). Fishery product logistics faces the challenge of quality degradation during the post-harvest phase, particularly in supply chain activities such as packaging, transportation, warehousing, and sales. This is caused by internal factors originating from the fishery products themselves, which are perishable foods, and external factors such as infrastructure, transportation, technology, and human resources. Quality degradation is also caused by several factors, such as post-harvest handling during the loading process at the delivery location, the shipping or distribution process, and the unloading process at the final consumer location (Pratama, Mustaruddin, & Purwangka, 2024a; Pratama, Mustaruddin, Purwangka, et al., 2024). One example of an inappropriate post-harvest handling process is using water with an unclear source for washing fishery products, which causes contamination by spoilage bacteria and accelerates the decay process in fishery commodities (Pratama, Mustaruddin, & Purwangka, 2024b).

The quality degradation that occurs during fisheries logistics activities also impacts the selling value and quantity of fishery products, resulting in a reduced quantity during post-harvest (food loss) (Pratama, Mayasari, et al., 2024). Numerous prior studies have demonstrated that food wastage is increasing in magnitude in developing countries, particularly in conjunction with limited utilization of cold chain logistics, when compared to developed nations (Kitinoaja L, 2013; Shabani et al., 2012). There has not been much investigation into why cold chains are not widely utilized in developing nations. It is thought that roughly a third of the world's total food output by weight is lost (Cederberg et al., 2011). In addition to the loss of consumer confidence due to food loss in the journey from upstream to downstream (Parfitt et al., 2010). Customers anticipate that the items they purchase will be delivered undamaged, in good condition, and punctually. The taste can be negatively affected, and decay may occur if temperatures vary while products are being transported. The importance of temperature in ensuring the preservation of food and its superior condition is widely recognized (Montanari, 2008; Ovca & Jevšnik, 2009). In low-income countries, the majority of food losses arise during production stages as a result of inadequate handling, storage, and transportation practices. In contrast, in developed countries, the primary losses occur at the consumption stage (Cederberg et al., 2011).

It's figured that nearly 40% of every food item requires a temperature-controlled supply network (Bremer, 2018). The ongoing issue of food wastage remains a significant problem within developing nations across the entire food production and distribution network. In many of these regions, cold chain infrastructure remains insufficient. Consequently, there is often a greater emphasis on enhancing food production to mitigate these losses and meet rising consumer demand, rather than on implementing technological advancements (Gligor et al., 2018). Kaipia et al., (2013). Estimates suggest that around 35% of the food produced is wasted across all stages of the supply chain, spanning from initial production to when it reaches the end consumer. To address the gap in previous research related to cold chains in developing countries, the researcher would like to dig deeper into the logistical and operational challenges in cold chain systems for fishery products in developing countries.

2. Research Methods

This study used a literature review method. A literature review is a research methodology designed to collect and analyze the key findings of prior studies, along with expert summaries presented in diverse texts (Nurislaminingsih et al., 2020). Data were collected through journal

searches using the keywords fishery product supply chain, fishery product safety, and fishery product cold chain system. The selected journals were tailored to the topic to be discussed, namely, the fishery product cold chain system. Furthermore, this literature review was synthesized using the narrative method by collecting similar extracted data to answer the research objectives of this study.

Location and Time of Research

This study employed Google Scholar, a platform for locating journal articles, to carry out the investigation via the internet. The journal search was conducted at the Faculty of Fisheries and Marine Science at Mulawarman University. This study was conducted from April to July 2025.

Types and Methods of Data Collection

Secondary data sources are used in this qualitative investigation. A collection of publications devoted to fishery product cold chain systems provided the secondary data that was utilized, fishery product supply chains, and fishery product safety. Data retrieval was performed using electronic databases such as Google Scholar. Purposive sampling was the method employed, and certain criteria were established. The criteria were the source of journals that discussed the cold chain system of fishery products. Fifty-five articles that met the criteria were used as references in this paper.

The literature selection process in this study is presented in detail through a PRISMA flow diagram (Figure 1). During the identification stage, a total of 280 records were retrieved, consisting of 235 articles from databases and 45 articles from registers. Prior to screening, 147 records were removed, including 55 duplicate articles, 47 records flagged as ineligible by automated tools, and 45 records excluded for other reasons. After the initial removal, 133 records proceeded to the screening stage, which involved title and abstract review. At this stage, 40 records were excluded due to irrelevance to the research topic. Subsequently, 93 articles were sought for full-text retrieval; however, 20 articles could not be retrieved and were therefore excluded from further analysis. A total of 73 full-text articles were assessed for eligibility. At this stage, 18 articles were excluded, including 10 articles that did not align with the research topic and 8 articles excluded for other reasons, such as methodological inconsistencies or insufficient information. Consequently, 55 studies met all inclusion criteria and were included in the final analysis of this systematic literature review.

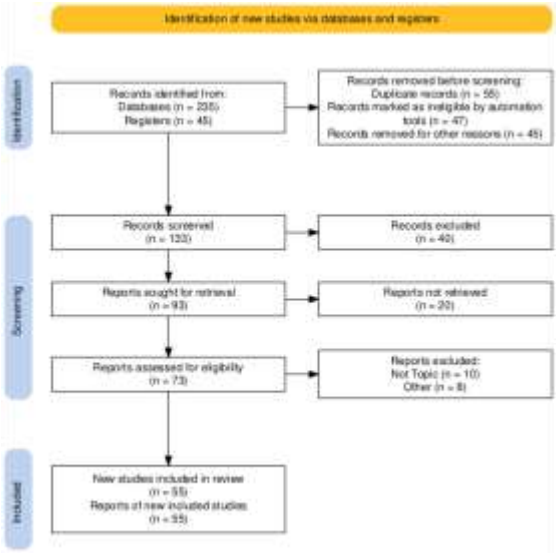

Figure 1: PRISMA Flow Diagram

Data Analysis Method

This study's data analysis used a methodical approach. This methodology entails the compilation of all relevant articles and the synthesis of each finding for enhanced clarity (Aveyard, 2011). The process commenced with a comprehensive summary of each reviewed piece of literature. Concurrently, a critical appraisal was performed to identify the strengths and weaknesses of each study and to examine the relationships among them.

3. Results And Discussion

Basic Concept of Cold Chain System

A crucial part of the supply chain that deals with perishable and temperature-sensitive goods is the cold chain. It is intended to keep these goods in a regulated setting, ensuring they remain within optimal temperature and humidity ranges. This process is essential for ensuring product safety, preserving value, and maximizing commercial potential (Joshi et al., 2011; Rodrigue, 2014; Salin & Nayga, 2003). The perishable nature of products is a critical component of the cold chain. Conversely, the transportation and storage of non-perishable goods that necessitate controlled low-temperature conditions are generally excluded from the cold chain (Shashi et al., 2021). The handling of perishable goods is the focus of cold chain management, a specialist area of supply chain management (Bogataj, 2005). It can be described as incorporating particular

traits and operations into a supply chain that already exists (Kuo & Chen, 2010).
Previous studies have noted that the cold chain comprises a series of linked steps, including packing, shipping, and keeping goods in conditions that adhere to defined criteria (Sopegno et al., 2018). Other studies have indicated that cold chains consist of an integration of processes, equipment, information management, and regulatory frameworks (Joshi et al., 2011; Montanari, 2008). Previous studies have largely centered their attention on the initial phases of the supply chain, specifically production and harvesting, that occur before the implementation of the cold chain system (Ahumada & Villalobos, 2009). This demonstrates that the supply chain's cold chain cannot be interrupted from the time of harvest or production to post-production, which includes packaging, warehousing, and distribution to the final consumer.

Fishery products are perishable and necessitate meticulous handling to maintain their quality. Consequently, for these products, the cold chain system needs to be carefully planned and effectively run. Otherwise, there will be various losses, such as spoilage, weight loss, softening of fishery products, changes in color and texture, physical degradation, bruising, and fungal and bacterial infections. All these factors affect the freshness, attractiveness, and marketability of the products (Pusporini & Dahdah, 2020). To ensure the quality of fishery products and mitigate potential losses, it is imperative to manage the post-harvest cold chain effectively. This process commences with the implementation of refrigerated transportation, storage, packaging, and temperature monitoring. The cold chain for fresh produce typically involves rapid refrigeration immediately after packaging, followed by transportation and storage at wholesale, retail, and consumer levels. Although there has been extensive research on precooling and storage have been extensive (Ambaw et al., 2013; Dehghannya et al., 2010; Norton et al., 2013; Smale et al., 2006). Transportation activities receive less attention in supply chain activities, even though they are a very important link in the cold chain (James et al., 2006; James & James, 2010). Fresh produce often undergoes long-distance refrigerated transport (Fitzgerald et al., 2011).

In numerous product categories, including fishery products, transportation under temperature-controlled conditions is essential rather than optional. Shipments frequently traverse longer routes to reach diverse regions and remote locations. Due to the unpredictable conditions during transit, it is common for shipments to pass through varying climate zones and areas with less developed transportation infrastructure. Shipments face additional challenges. All these factors can lead to high costs for the successful delivery of items. In these challenging conditions, the success of a shipment largely depends on selecting the appropriate packaging for each product and anticipating the potential circumstances during transportation (Zhao et al., 2020). Continuous monitoring of transportation vehicles, monitoring critical parameters, such as temperature, is essential for ensuring proper transportation and preserving product quality. This aspect must be prioritized to achieve the successful delivery of fishery products. Although the shipping process often relies on product packaging, it often overlooks the importance of temperature monitoring. The packaging of fishery products is essential; however, it represents only one aspect of maintaining a safe and temperature-controlled shipment. Despite employing the most effective packaging solutions, various uncertainties during transportation can lead to temperature fluctuations that exceed the intended range, potentially compromising the integrity of the fishery products. Therefore, continuous temperature monitoring is essential to provide insights and enable quick corrective actions in the event of temperature changes that could damage the fishery product. In addition to monitoring temperature during transportation, it is equally important to track it during storage, as temperature-sensitive products can be compromised upon receipt or during storage. Therefore, establishing optimal conditions for storing fishery products is essential. Achieving these appropriate storage conditions requires the implementation of measuring and tracking devices (Pajić et al., 2024).

Temperature profiles throughout the supply chain are critical in assessing the quality and safety of fresh produce (Giannakourou et al., 2001). In addition to the temperature control of fishery products, the cold chain's significant potential remains largely underutilized. This is due to several factors, including the prevalence of stand-alone refrigeration units, inadequate infrastructure such as transportation networks, insufficiently trained personnel to manage perishable items, and suboptimal services from warehouses and transport providers, all of which ultimately compromise product quality (Andrejic, 2016). According to Pajić et al., (2024). Some of the key factors in maintaining the cold chain in shipping fishery products include the following:

a. Product preparation
   Several factors are taken into account when assessing the features related to moving items that can be affected by temperature. It is particularly important to consider the atmospheric conditions leading up to the shipping phase, especially for goods vulnerable to significant temperature changes, like high temperatures during transit. Refrigerated vehicles with self-powered units are commonly used to address these concerns.
b. Transportation
   Various factors are important to consider when determining the mode of transportation for shipping fishery products. Several factors will influence the available transportation options, including the distance from the starting point to the final destination, the size and weight of the load, the necessary external temperature conditions, and the perishability of the product. The ratio between cost and the rate at which the product becomes spoiled is also a significant consideration.
c. Procedure inspection
   Because cold chain products, such as fishery products, are more sensitive to weather factors than other goods, fishery products must undergo thorough inspections, and monitoring throughout the transportation process is essential for preserving cold chain integrity, particularly during procedures specifically implemented for this objective.
d. Last mile
   The term refers to the delivery of goods to their final destination during the concluding segment of the transportation process, commonly referred to as the "last mile." Given the importance of delivery time and ensuring that the product reaches its intended destination, it is imperative to ensure the availability of receiving points at the destination.
e. Maintain integrity and quality assurance
   Establishing the required temperature entails a logistical process that builds trust among partners while delineating responsibilities, particularly in relation to accountability for any damage to fishery product shipments. In the event of issues, the emphasis should be on identifying the source of the problem and determining the appropriate corrective actions to address it.

Logistics Challenges in the Cold Chain

The cold chain possesses several key characteristics, including the limited shelf life of products and their perishable nature, the need for controlled transportation and storage, and attention to safety aspects (Aramyan et al., 2007). Food safety regulations include the temperature control of fishery products throughout the supply chain, temperature tracking of fishery products in refrigerated vehicles, production work areas, loading and unloading points, and the use of standardized equipment (Bogataj, 2005). In addition, there are several logistical challenges in the cold chain that occur in developing countries, such as infrastructure, transportation, and technology.

Infrastructure

High-quality fishery products require appropriate and adequate cold chain infrastructure. However, the effective implementation of cold chain management remains constrained by the lack of availability or adequacy of cold chain facilities, particularly in developing countries (Kitinoaja L, 2013). Adequate facilities and infrastructure to monitor fishery products during the harvest process are essential at every critical control point in the cold supply chain. Research has identified that such bottlenecks can be caused by a lack of cold storage facilities, such as warehouses or cold rooms (Balaji & Arshinder, 2016; Salin & Nayga, 2003). Limited supply of electricity and water resources (Joshi et al., 2009). Lack of an integrated information technology system and lack of a traceability system (Balaji & Arshinder, 2016; Cousins & Menguc, 2006; Sharma & Pai, 2015; Shashi et al., 2018). In addition, the availability of adequate infrastructure is affected by financing in the procurement process. Financial barriers contributing to inefficient cold chain management include the significant expenses related to cold chain infrastructure, such as cold storage facilities and temperature control systems (Joshi et al., 2009; Kuo & Chen, 2010; Salin & Nayga, 2003; Shashi et al., 2018; Singh et al., 2018). While cold chains can improve the quality maintenance of fishery products, they require larger capital investments in storage and transportation facilities, as well as higher operational costs. The high operational costs include the logistics of running such infrastructure (Salin & Nayga, 2003; Singh et al., 2018; Zanoni & Zavanella, 2012). One reason for the underdevelopment of cold chains in developing countries is the lack of adequate infrastructure (Gligor et al., 2018). A well-developed cold chain infrastructure significantly improves the quality of fishery products and reduces losses, lead times, and other costs. Overall, studies suggest that financial factors are the most crucial barriers to efficient cold chain management for fishery products. This includes the high costs of infrastructure, maintenance, and distribution (Hafidz et al., 2025). In addition, infrastructure is closely related to roads as a distribution channel. For example, in Vietnam, where 70 percent of the

population lives in rural areas, unlike metropolitan areas where highways and toll roads are available and rapidly developing, remote areas lack infrastructure such as roads and logistics systems, which hinder the process of delivering products and reaching consumers efficiently (Gligor et al., 2018). According to the World Economic Forum (WEF), (2008) among various types of infrastructure, Vietnam is considered to have the worst quality in terms of ports, roads, and electricity. In the Philippines, an archipelago, the distribution process must use land or water transportation to reach the southern provinces of the country. The high cost of inter-island transportation is a major challenge in implementing cold chain systems in the Philippines. In Thailand, considerable distances must be traveled between the capital city and smaller towns. Owing to the high cost of fuel, distribution by truck to small towns is very expensive (Salin & Nayga, 2003). Here are several comparisons of infrastructure in developing countries, as presented in Table 1 below:

TABLE 1
INFRASTRUCTURE COMPARISON IN DEVELOPING COUNTRIES

Area	Cold Chain Infrastructure Conditions	Key Infrastructure Challenges	Impact on Cold Chain Logistics	Reference
South Asia (India, Bangladesh)	Limited cold storage capacity, conventional refrigeration technology	Limited refrigerated storage facilities, inadequate refrigerated transportation	High losses of perishable products and declining product quality	(Rangar et al., 2025; Roy, 2025)
Southeast Asia (Indonesia, Philippines, Vietnam, Thailand)	Infrastructure is available but unevenly distributed	Archipelagic geography, fragmented distribution, limited access in rural areas	Distribution inefficiencies and temperature instability during transportation	(Aung & Chang, 2014; Kitinoja & Kader, 2015)
East Asia (China)	Relatively well developed infrastructure with high investment	Disparities in quality and operational standards across regions	Inconsistencies in temperature control and product quality	(Chen et al., 2025; Cheng et al., 2024; Gao et al., 2025)
Central Asia (Kazakhstan, Uzbekistan)	Cold chain infrastructure remains limited	Limited energy supply and minimal adoption of modern refrigeration technology	Low cold chain performance and high risk of product spoilage	(Brauweiler et al., 2023; Wiederer & Straube, 2019)

Transportation

From manufacture or processing through all phases of transportation, including loading, unloading, handling, and storage, the integrity of the cold chain must be preserved. In addition, it's critical to keep an eye on temperatures, install and maintain equipment, guarantee timely product movement, link refrigerated vehicles to a power supply, and keep cold storage unit doors firmly closed (Salin & Nayga, 2003). Transportation is intrinsically connected to the availability of goods and services for consumption, positioning it as a critical component of all economic activities (Numani et al., 2025). Transportation plays a vital role in the economy by enhancing market accessibility and connecting producers with consumers. An efficient transportation system that improves cost, speed, and reliability facilitates the prompt delivery of products (Tunde & Adeniyi, 2012). Transportation is important because it is one of the stages in the post-harvest production of fishery products that are only considered complete when the commodity has reached the final consumer.

Logistics has transitioned from a production-oriented approach to a customer-centric model. With the increasing volume of shipments to customers, transportation costs have risen, while both shipment sizes and delivery times have diminished. This shift underscores the necessity to develop cost-effective, mass-customized logistics services within the food supply chain (Kuo & Chen, 2010). The supply chain for fishery products possesses several key characteristics, including the limited shelf life of raw materials, product perishability, the necessity for specific transportation and storage conditions, and an emphasis on safety considerations (Aramyan et al., 2007). Therefore, the application of a cold chain system is also necessary for the transportation of fish products. According to Hanafiah et al. (2024), in the process of shipping fishery products, there are several types of refrigerated transportation units used in developing countries, including Thermo King trucks, common trucks, and reefer container trucks.

Various transportation technologies have been developed and refined for the transport of cold-chain goods. The most commonly utilized methods include refrigerated vehicles, such as trucks, and containers, including maritime containers and unit load devices for air transportation. These technologies generally rely on an integrated refrigeration system powered by an electrical generator (Rodrigue, 2014). All transportation systems must uphold product temperatures within

certain bounds to guarantee maximum shelf life and safety. The market for chilled food has grown rapidly thanks in large part to advancements in temperature-controlled transportation (James & James, 2010).

Transportation is considered an important factor in the development of fishery product distribution, as it is the only way to move fishery products from the harvest site to households and markets. Transportation facilitates the establishment of markets for fishery products, enhances interactions between geographic and economic regions, and creates new opportunities for economic development. The relationship between transportation and development is intricate and varies across different locations and time periods. However, transportation plays a crucial role in any development process (Tunde & Adeniyi, 2012). Inadequate transportation in rural areas has led to reduced productivity and income, a decline in the welfare of the rural population, and an escalation of poverty levels. Previous research has identified several problems in transportation. These problems include damaged roads, high transportation costs, irregularity of vehicles, an insufficient number of vehicles, a lack of transportation facilities, and long distances from harvesting sites to homes and markets (Tunde & Adeniyi, 2012). Here are several comparisons of transportation in developing countries, as presented in Table 2 below:

TABLE 2
COMPARISON OF REFRIGERATED TRANSPORTATION MODES IN THE COLD CHAIN IN DEVELOPING COUNTRIES

Transportation Mode	Key Characteristics	Advantages	Limitations in Developing Countries	Impact on Product Quality	Source
Refrigerated Land Transportation (Refrigerated Trucks)	Uses refrigerated trucks with active temperature control	Flexible, suitable for short to medium distance distribution	Limited fleet availability, poor road conditions, and high operational costs	Temperature fluctuations increase the risk of quality deterioration and food loss	(Aung & Chang, 2014)
Refrigerated Sea Transportation (Reefer Ships and Reefer Containers)	Transportation using dedicated vessels or refrigerated containers	Efficient for large volumes and long distances	Limited availability of ports with cold chain facilities and long transit times	Risk of quality degradation due to delays and power disruptions	(Kitinoja & Kader, 2015)
Refrigerated Air Transportation (Air Freight)	Fast delivery with strict temperature control	Short transit time, suitable for high-value products	Very high costs and limited access in developing countries	Product quality is relatively well maintained, but it is not economical for large volumes	(Hu et al., 2024)
Refrigerated Intermodal Transportation	A combination of land, sea, and air transportation with an integrated cold chain	Enhances cross-regional distribution efficiency	Weak system integration and non-uniform operational standards	Risk of temperature abuse at modal transfer points	(Shi et al., 2024)

Technology

Cold chain storage and distribution technology has become an important element in the management of fishery products. The cold chain refers to the system used to maintain products at an appropriate temperature during storage and distribution. This technology is particularly essential for perishable items, such as fishery products (Ouyang et al., 2020). The implementation of a cold chain is intended to maintain the freshness, quality, and nutritional value of fishery products throughout the entire process from production to consumption (Khan et al., 2025). High temperatures in most parts of the country lead to accelerated product deterioration, particularly for temperature-sensitive products. Cold chain technology is a key solution to ensure that fishery products remain in optimal condition until they reach domestic and international markets (Khan et al., 2025). Technological advancements in the cold chain now enable real-time monitoring of temperature and humidity throughout storage and transportation processes (Mishra et al., 2021).

The utilization of this technology helps prevent premature spoilage and economic losses caused by improper food storage. However, in developing countries, the utilization of technology to support cold supply chains faces obstacles that make implementation difficult. Participants in the cold supply chain have raised concerns regarding the considerable installation and operational costs linked to cold-chain systems. The primary obstacles to the development of the cold chain in Vietnam include the high initial capital expenditures and substantial operational costs associated with refrigeration units. Most industrial equipment and technologies are imported from overseas. To alleviate the impact of current domestic tariffs,

importers or their representatives maintain only a limited inventory of equipment within the country. This combination of elevated equipment costs and import duties deters companies from investing in and developing refrigeration systems and their associated control systems (Gligor et al., 2018). Research on cold chains in developed countries has highlighted the intricate role of information technology within these systems. Consequently, local companies in developing countries are required to allocate additional resources to integrate all participants in the supply chain through shared information systems that enable real-time communication (Gligor et al., 2018).

Human Resources

Any supply chain system's foundation is its human resources (HR), which are essential to the smooth operation of all other components (Kasonde & Steele, 2017). Several supply chain stakeholders emphasized the critical importance of specific roles within their organizations that require substantial investment in human capital, both in quality and quantity. These roles encompass operators, maintenance technicians, cold chain logistics experts, and fisheries specialists, as well as the necessity of adhering to hazard analysis and Hazard Analysis Critical Control Point (HACCP) standards. HACCP is a systematic, science-based methodology employed to identify specific hazards and establish control measures that ensure food safety.

A food firm’s executive voiced concerns regarding his workforce’s inability to precisely follow the guidelines for keeping milk fresh. He pointed out that the primary reason was that workers were not sufficiently informed about how temperature affects how good the product. Those surveyed knew about the issues resulting from the Vietnamese food sector’s divided and chaotic structure (Gligor et al., 2018). This shows that, in addition to infrastructure, human resource capacity building is also an important factor in the successful implementation of cold chains across the country (Khan et al., 2025).

Implications and Recommendations

Logistical challenges in the implementation of cold chain systems for fishery products in developing countries require improvement, starting from infrastructure, including both roads that connect regions to facilitate the distribution process of fishery products with cold chain systems. In addition, improving the quality and capacity of human resources in the fishery product supply chain is needed to maintain monitoring during supply chain activities and the quality of fishery products during distribution activities. Technology is one of the important factors in addressing logistical challenges in the implementation of cold chain systems; therefore, the application of technology in maintaining the quality of fishery products during distribution activities must continue to develop and be integrated into every fishery product supply chain activity.

4. Conclusion

Cold supply chains for fishery products in developing countries continue to face implementation challenges. There are several logistical challenges in implementing cold chains for fishery products, such as infrastructure, transportation, technology, and human resources. Infrastructure, such as roads that cannot connect regions, is an obstacle in the implementation of a cold chain for fishery products. In addition, transportation that does not meet cold chain shipping standards adds challenges to cold supply chain activities. The application of technology that requires development and investment of funds is also a challenge for developing countries in the implementation of cold chains. Human resources that do not understand the importance of maintaining the quality of fishery products during post-harvest cause logistical challenges in the cold

chain system of fishery products in developing countries. Therefore, it is necessary to improve the road infrastructure that connects regions, improve the quality and capacity of human resources, invest in and apply modern technology focused on an integrated cold chain, and use standardized transportation in cold chain delivery. This aims to maintain the quality and quantity of post-harvest fishery products and increase their competitiveness in the fishery products.

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