

Review and Progress

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Safety and Automation in Singapore's Local Fish Production: Opportunities and Challenges for Sustainable Aquaculture Development

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Abstract Singapore aims to increase its local food production to 30% by 2030, with a strategic focus beginning on fish and shrimp production. Challenges from rising labour costs and limited space for sustainable aquaculture present significant obstacles. This process review highlights current technologies for fish sorting and harvesting and assesses the potential for automation in onshore fish farming. It also examines the fish farming process, scrutinises safety practices and standards, and applies a risk assessment framework for selected aquaculture activities, notably for feeding and harvesting activities, and offers insights into the global aquaculture industry, offering a strategic standpoint for increasing local fish production, reinforcing food safety, and support the sustainability of the aquaculture sector. To achieve the 30% local food production target by 2030, Singapore needs to address geographic limitations, supply-chain dependence, labour costs, and energy consumption. Thus, embracing urban environments, ensuring product freshness, and implementing advanced technologies like auto-feeders, IoT, and recirculating systems are important approaches for supporting the expansion of the local aquaculture industry. Alongside these opportunities, this review also considers capital cost, energy intensity, workforce competency, maintenance burden, and cybersecurity exposure as practical constraints on adoption. This review is expected to provide a practical plan to integrating automation technologies, safety management practices, and sustainable production strategies in urban aquaculture development.

Keywords Food safety; Local produce target; Fish farming processes; Automation in aquaculture; Fish farming industry; Onshore fish farming

1 Introduction

Food security concerns and potential disruptions to global supply chains have encouraged Singapore to increase local food production from 10% to 30% by 2030. Fish and shrimp are an important source of this food, but the main challenges are labour cost and the space available for sustainable aquaculture. This study sets out to understand the processes of fish farming and to identify where automation may be applied across breeding, rearing and transportation. A key objective is to identify and understand existing technologies and solutions for fish sorting and harvesting. A third aim is to characterise the onshore fish-farming industry in Singapore, identifying the key players in the aquaculture value chain and the automation opportunities in onshore farming. The research follows a structured approach, beginning with the challenges and opportunities in aquaculture both locally and globally, then examining the fish-farming process, reviewing the prevailing safety practices and standards, and culminating in a risk assessment of two pivotal activities: feeding and harvesting. The insights are intended to strengthen understanding of the aquaculture industry in Singapore and worldwide, and to inform strategies for increasing local fish production, reinforcing food safety and supporting the sector.

Internationally, the aquaculture sector has moved rapidly towards what is variously described as smart, precision or digital aquaculture. Reviews of Internet of Things (IoT)-based smart aquaculture management systems describe sensor networks, software interfacing, artificial intelligence, cloud computing and data storage as the constituent technologies of contemporary farm monitoring, and identify water quality management, feeding behaviour monitoring and animal health surveillance as the dominant application areas (Yadav et al., 2023). Parallel work on the energy performance of land-based systems has drawn attention to the fact that the water-efficiency gains of