Assessing In-Flight Food Waste Management Practices of Major Airlines Operating Direct Flights to Auckland: A Comparative Study Under New Zealand's Border Security

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A dissertation submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of International Hospitality Management

2026

School of Hospitality and Tourism

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Abstract

In-flight food waste has become an important environmental, operational, and biosecurity challenge for the international aviation industry. This study examined how major airlines operating direct flights to Auckland, New Zealand (Air New Zealand, Emirates, Qantas, Singapore Airlines, and China Southern Airlines) manage in-flight food waste within New Zealand's stringent biosecurity framework and how these practices align with broader sustainability and Circular Economy objectives. Guided by the Circular Economy framework, the research adopted an interpretivist qualitative case study design based exclusively on secondary documentary data. Documentary evidence was collected from airline sustainability reports, annual reports, regulatory publications, airport operational documents, and industry reports. The data were analysed using hybrid thematic analysis, combining deductive and limited inductive coding with the support of NVivo 15.4. The analysis identified eight interconnected themes: Food Waste Reduction, Circular Economy, Sustainability Strategies, Waste Management Practices, Biosecurity Compliance, Regulatory Constraints, Stakeholder Collaboration, and Resource Efficiency. The findings indicate that all five airlines have integrated food waste reduction into their sustainability and operational strategies through initiatives such as meal forecasting, waste monitoring, inventory optimisation, resource efficiency, sustainable packaging, and the use of digital technologies. However, the study also found that New Zealand's strict biosecurity regulations governing international catering waste significantly constrain opportunities for recycling, composting, food redistribution, and the broader implementation of the Circular Economy. The study concludes that sustainable airline food waste management requires balancing environmental sustainability with national biosecurity responsibilities. While airlines demonstrate a strong commitment to improving sustainability, implementing Circular Economy principles successfully depends not only on organisational initiatives but also on stakeholder collaboration, technological innovation, and supportive regulatory frameworks. This dissertation adds to the growing body of knowledge on sustainable aviation by providing practical and theoretical insights into managing in-flight food waste within a highly regulated biosecurity environment.

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Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."

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STUDENT DECLARATION

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Acknowledgement

I would like to express my sincere gratitude to my supervisor, Dr Tracy Harkison, for her continuous support, patience, guidance, and encouragement throughout this research journey. Her feedback and direction have been extremely valuable in helping me develop and complete this dissertation.

I would also like to sincerely thank Brett Heagren for his understanding and support during a particularly difficult period of my studies. When I had to travel to India due to a family medical emergency, his assistance in arranging an extension to my dissertation timeline provided me with the time and flexibility I needed to support my family and continue my research. I am extremely grateful for the understanding and support he provided during this challenging period.

I am deeply grateful to my parents for their strength, encouragement, and continued support throughout my studies. Despite facing a difficult medical situation as a family, they remained strong and continued encouraging me to focus on my studies and complete my research. Their support and belief in me have meant more to me than I can express.

A very special thank you goes to my lovely wife, Chathuri, for her constant emotional support, patience, and encouragement throughout my dissertation. She managed so many responsibilities herself while continuing to support me during the demanding stages of my research. Her understanding and support have meant a great deal to me throughout this journey.

I would also like to thank my cousin, Gilbert, for always being there for me and supporting me throughout this journey. His encouragement and willingness to help whenever I needed it made a real difference, and I am very grateful for his support.

Finally, I would like to thank everyone who supported and encouraged me throughout this journey and contributed, directly or indirectly, to the completion of this dissertation.

Chapter 1: Introduction

The aviation industry plays a fundamental role in facilitating international trade, tourism, and global connectivity. However, the continued growth of international air travel has also increased environmental challenges, including the generation of in-flight food waste. As sustainability becomes a strategic priority within the aviation sector, airlines are increasingly expected to balance environmental responsibility with operational efficiency and regulatory compliance. This chapter introduces the background to the study, outlines the research problem, presents the research aim and research questions, and explains the significance of the research. The chapter concludes by outlining the structure of the dissertation.

1.1 Research Background of the Study

The aviation industry has experienced significant growth over recent decades and has become one of the world's most important sectors for facilitating international trade, tourism, and global connectivity (Samunderu, 2024). The expansion of air transport has accelerated the movement of people and goods across international borders, contributing significantly to economic development and globalisation (Zhang & Graham, 2020). Following the disruption caused by the COVID-19 pandemic, the aviation industry has progressively recovered, with international passenger demand and flight operations continuing to increase (Samunderu, 2024). Although this growth has strengthened global mobility, it has also intensified the environmental challenges associated with aviation operations (Dube et al., 2021). To date, sustainability initiatives within the aviation industry have primarily focused on reducing carbon emissions, improving fuel efficiency, and supporting decarbonisation strategies (Abrantes et al., 2021; Sharmina et al., 2021). However, operational waste generated through airline activities has emerged as another significant environmental challenge requiring greater research and industry attention (Blanca-Alcubilla et al., 2019; Salesa et al., 2023).

One of the major waste streams generated by airline operations is in-flight food waste. Airline cabin waste consists primarily of leftover food, organic waste, plastic packaging, paper products, disposable service items, and catering materials (Blanca-Alcubilla et al., 2019). As international aviation continues to expand, particularly on long-haul routes, the volume of in-flight food waste is expected to increase. Blanca-Alcubilla et al. (2019) observed that waste generation is closely associated with flight duration, with longer flights producing larger quantities of food waste, packaging materials, and paper products because of increased catering requirements. Consequently, the continued growth of international aviation is expected to increase both the volume and complexity of airline food waste (Li, 2024; Salesa et al., 2023).

Food waste is not unique to the aviation industry but represents a broader sustainability challenge across the hospitality and food-service sectors. Dhir et al. (2020) and Filimonau and De Coteau (2019) reported

that avoidable food waste commonly results from overproduction, inaccurate demand forecasting, operational practices, and consumer behaviour. Similar challenges exist within airline catering operations, where uncertainty regarding passenger demand and the need to maintain high service standards frequently result in excess meal provisioning. You et al. (2020) further explained that changing passenger preferences, meal selection, consumption behaviour, and customer satisfaction considerations contribute to food waste generated during flights. Consequently, airlines frequently load additional meals to minimise the risk of shortages during service, resulting in surplus food that remains unconsumed and is discarded after arrival (You et al., 2020).

Food waste has significant environmental consequences throughout the food supply chain. It contributes to greenhouse gas emissions during food production, transportation, consumption, and disposal while simultaneously wasting valuable resources such as water, energy, labour, and raw materials (Bhatia et al., 2023). Waste management within the aviation sector is particularly challenging because food waste is frequently mixed with plastics and other catering materials, reducing opportunities for recycling and resource recovery (Blanca-Alcubilla et al., 2019). Furthermore, Pennington et al. (2025) noted that waste generated from international flights is often disposed of through landfill or incineration because of national biosecurity requirements. These disposal practices increase environmental impacts while limiting opportunities for reuse, recycling, and resource recovery. Consequently, identifying more sustainable approaches to food waste management has become increasingly important for reducing the environmental impacts of aviation while operating within these regulatory constraints (Pennington et al., 2025).

Growing environmental concerns have also increased expectations for airlines to improve their sustainability performance. Governments, regulatory authorities, environmental organisations, and consumers increasingly expect airlines to reduce their environmental footprint and adopt more sustainable operational practices (Amankwah-Amoah, 2020). Consequently, sustainability within aviation now extends beyond emissions reduction to include waste minimisation, resource efficiency, and the application of Circular Economy principles. These principles promote strategies that minimise waste generation by reducing, reusing, recovering, and recycling resources wherever possible (Geissdoerfer et al., 2020; Kirchherr et al., 2017). Within the aviation industry, these principles are reflected in initiatives such as reducing single-use plastics, redesigning catering systems, improving meal forecasting, and implementing waste segregation programmes (Salesa et al., 2023).

The Circular Economy (CE) provides a sustainability framework that challenges the traditional linear model of resource consumption, in which materials are extracted, used, and discarded. Kirchherr et al. (2017) conceptualised CE as an approach that replaces end-of-life disposal with strategies that reduce resource consumption, extend material use, and recover value from waste. Blomsma and Brennan (2017) further positioned CE within the broader development of resource-efficiency and waste-

management thinking, while Korhonen et al. (2018) highlighted the importance of recognising the environmental and practical limitations of circular systems. In airline catering operations, this framework is particularly relevant because food waste can be addressed through improved meal forecasting, reduced over-catering, efficient resource utilisation, and the recovery of suitable materials (Salesa et al., 2023). However, the application of CE principles to international catering waste is complicated by biosecurity requirements, which may restrict recycling, composting, and other recovery options (Pennington et al., 2025). Consequently, the CE framework provides a basis for examining both opportunities for waste prevention and the regulatory constraints affecting sustainable airline food waste management.

Many airlines have already begun incorporating Circular Economy principles into their sustainability strategies. Baxter et al. (2021) noted that Finnair introduced initiatives to improve onboard recycling and enhance the sustainability of its catering operations. Similarly, Salesa et al. (2023) reported that airlines are increasingly adopting innovative approaches, such as recycling in-cabin waste, sustainable packaging, meal booking systems, and waste segregation, to minimise waste generation and strengthen environmental performance. Technological developments, including machine learning and predictive analytics, are also being explored to improve meal forecasting and reduce unnecessary catering waste (Aghazadeh, 2025; Rodrigues et al., 2024). Despite these developments, achieving sustainable waste management within international aviation remains challenging because any environmental initiatives must also comply with the strict food safety and biosecurity requirements imposed by destination countries.

International catering waste (ICW) is recognised as one of the most complex waste streams generated by international aviation because it may contain food waste, animal products, plant materials, pests, pathogens, and other materials capable of introducing biosecurity risks across national borders (IATA, 2024a; Pennington et al., 2025). Hulme (2009) argued that international transport systems, particularly aviation, create significant pathways for biological invasions, while Hall (2011) highlighted that tourism and increasing global mobility present substantial biosecurity risks, particularly for environmentally sensitive island nations (MPI, 2025; Riasari et al., 2021).

New Zealand operates one of the world's most stringent biosecurity systems because of its geographical isolation, unique biodiversity, and the importance of protecting its agricultural industries (Leuprecht et al., 2022). Effective biosecurity is therefore essential for safeguarding New Zealand's economy, environment, and national security (Stone, 2021). The Ministry for Primary Industries (MPI) regulates the handling, transportation, treatment, and disposal of international catering waste to minimise the introduction of harmful pests and diseases into New Zealand (Stone, 2021). These regulations require international airline catering waste to be managed under strict biosecurity controls throughout the waste management process.

1.2 Problem Statements

The aviation industry has made considerable progress in improving environmental sustainability through initiatives such as carbon emission reduction, fleet modernisation, and the adoption of sustainable aviation fuels (Abrantes et al., 2021; Gössling & Higham, 2021). However, less attention has been given to the management of operational waste, particularly in-flight food waste, which presents complex environmental and operational challenges for the aviation industry (Ismael et al., 2025; Salesa et al., 2023). Previous studies have shown that airline food waste is influenced by operational inefficiencies, passenger demand uncertainty, service quality expectations, and increasing environmental and regulatory pressures (Korhonen et al., 2018; Pennington et al., 2025; Salesa et al., 2023). Although food waste has become an increasingly important sustainability issue within aviation, research examining practical strategies for managing in-flight food waste remains limited.

While Circular Economy principles encourage waste prevention, resource efficiency, reuse, recycling, and resource recovery, their implementation within international aviation is constrained by strict food safety and biosecurity regulations governing international catering waste (Blomsma & Brennan, 2017; Geissdoerfer et al., 2020; Korhonen et al., 2018; Pieroni et al., 2019). Consequently, airlines face increasing challenges in balancing sustainability objectives with regulatory compliance.

This challenge is particularly evident in New Zealand, where international catering waste must be managed under strict biosecurity controls to minimise the introduction of harmful pests and diseases (MPI, 2025). While these regulations are essential for protecting New Zealand's environment, agriculture, and economy, they also limit opportunities for recycling, composting, and resource recovery.

Although previous studies have examined aviation sustainability, food waste management, and Circular Economy practices independently (Korhonen et al., 2018; Geissdoerfer et al., 2020; Salesa et al., 2023), the interaction between in-flight food waste management, sustainability and Circular Economy practices, and biosecurity compliance remains underexplored in the context of international airlines operating direct flights to Auckland. This represents an important gap in the existing literature and provides the basis for the present study.

1.3 Research Question and Aims

This study aims to examine how five major international airlines operating direct flights to Auckland manage in-flight food waste within the context of New Zealand's biosecurity regulations. It further aims to explore how airline food waste management practices align or conflict with broader sustainability objectives and Circular Economy principles. By examining the sustainability reports, annual reports, and regulatory documents of the selected airlines, the study seeks to understand how international carriers respond to New Zealand's controlled international catering waste requirements while

identifying opportunities to improve sustainable food waste management within a highly regulated aviation environment.

Research Questions

1. How do five major international airlines operating direct flights to Auckland manage in-flight food waste within the constraints of New Zealand's biosecurity regulations?
2. In what ways do New Zealand biosecurity requirements shape airline strategies for waste reduction and disposal?
3. What opportunities exist to align compliance obligations with sustainability and Circular Economy objectives in the context of international catering waste?

1.4 Significance and Rationale of the Study

This study adds to the growing body of knowledge on aviation sustainability, in-flight food waste management, Circular Economy, and biosecurity governance within international airline operations. While previous research has examined these areas independently, their interaction remains underexplored within the context of international airlines operating under New Zealand's stringent biosecurity requirements. By addressing this gap, the study extends existing knowledge on the relationship between environmental sustainability and biosecurity compliance within international catering waste management.

The findings aim to provide practical value for airlines operating direct international services to Auckland by improving understanding of current food waste management practices within a highly regulated biosecurity environment. The study could also inform airport authorities, airline catering providers, policymakers, and biosecurity agencies in identifying opportunities to strengthen sustainable waste management while maintaining compliance with New Zealand's biosecurity regulations. In particular, it may help identify opportunities for airline waste management to integrate Circular Economy principles in ways that align with regulatory requirements, including waste reduction, resource recovery, recycling, and improved operational efficiency.

This study also contributes to the broader policy and sustainability discourse by providing evidence on the challenges and opportunities of balancing environmental sustainability and biosecurity protection in international aviation. Finally, the findings provide a foundation for future research examining sustainable airline waste management, Circular Economy implementation, and international catering waste management practices in other countries operating under similarly stringent biosecurity frameworks.

1.5 Dissertation Structure

This dissertation is organised into five chapters. This chapter has introduced the research by providing the background, aim, research questions, significance of the study, and the overall structure of the dissertation. Chapter Two reviews the relevant literature on aviation sustainability, in-flight food waste management, Circular Economy principles, and New Zealand's biosecurity framework. It also identifies the research gap and presents the theoretical foundation underpinning the study.

Chapter Three outlines the research methodology adopted for the study, including the research philosophy, research approach, research design, case selection, data collection process, and thematic data analysis using NVivo 15.4. Chapter Four presents the findings and discussion arising from the documentary analysis of the five selected airline cases, integrating the findings with the existing literature and the Circular Economy framework. Finally, Chapter Five summarises the key findings, presents the conclusions of the study, discusses the theoretical and practical implications, acknowledges the limitations of the research, and provides recommendations for future research and industry practice.

Chapter 2: Literature Review

2.1 Introduction

This chapter reviews the literature relevant to in-flight food waste management in the commercial aviation industry and establishes the theoretical foundation for the study. The review begins by examining the concepts, definitions, operational waste classifications, scale, and causes of airline food waste in international aviation operations (IATA, 2024b; McIlwee, 2026). This is followed by a discussion of the environmental impacts of aviation food waste and a critical examination of industry-wide sustainability practices, waste-reduction initiatives, and resource-efficiency strategies adopted by commercial carriers (Blanca-Alcubilla et al., 2019; Salesa et al., 2023).

The chapter then introduces the Circular Economy framework as the study's theoretical foundation, evaluating its core principles, operational applications, and practical limitations within aviation waste management (Geissdoerfer et al., 2020; Kirchherr et al., 2017). This provides a basis for understanding how airlines can move beyond conventional waste disposal towards waste prevention, resource efficiency, reuse, recycling, and resource recovery. The review then examines the biosecurity and regulatory requirements governing international catering waste and considers how these requirements can affect the implementation of sustainable and Circular Economy practices (ICAO, 2022; Pennington et al., 2025).

Finally, the interaction between sustainability objectives and biosecurity compliance is examined within the New Zealand context, establishing a research gap concerning how airlines operating direct international services to Auckland manage in-flight food waste while pursuing sustainability and Circular Economy objectives within a highly regulated biosecurity environment (Baxter, 2020; MPI, 2025). The chapter therefore develops from understanding the problem of in-flight food waste, through the sustainability approaches available to airlines, to the regulatory conditions that influence how these approaches can be implemented before identifying the research gap addressed by this study.

2.2 In-Flight Food Waste in the Aviation Industry

In-flight food waste has become an increasingly important sustainability issue within the aviation industry due to the continued growth of international air travel and onboard catering services. Understanding the nature, sources, and characteristics of airline food waste is essential when examining its environmental impacts, operational challenges, and management practices. This section presents the established definition and classification of aviation food waste and examines its scale, principal causes, and environmental impacts within commercial aviation.

2.2.1 Definition of Aviation Food Waste

As global aviation travel has expanded, the provision of in-flight meals and catering services has become an essential component of airline passenger service (Hwang et al., 2023; IATA, 2024b). However, this growth has substantially increased the volume of waste generated onboard commercial aircraft (IATA, 2024b). Aircraft waste is generally classified into two broad operational categories: cleaning waste and catering waste (Hwang et al., 2023). Cleaning waste consists of general cabin refuse generated by passengers, such as newspapers, tissues, plastic bottles, and paper items (Hwang et al., 2023; IATA, 2019). In contrast, catering waste refers to materials arising from onboard food and beverage service, including unconsumed meals, food residues, packaging materials, and disposable food-service items such as plates and cutlery (IATA, 2024b; McIlwee, 2026).

A specific component of catering waste is airline food waste, which refers strictly to edible food and beverage products that remain unconsumed or partially used following flight operations (McIlwee, 2026). Throughout this study, aviation food waste refers specifically to edible food and beverage products that remain unconsumed or partially consumed, while catering waste encompasses the broader operational service stream, including food residues, packaging, and food-service materials (IATA, 2024b; McIlwee, 2026). Table 2.1 distinguishes the principal aircraft waste streams according to their operational definition, the materials included within each waste category (material scope), and the primary regulatory framework governing their management. This distinction is important because different waste streams are subject to different operational and regulatory requirements.

Table 2.1: Operational Definitions of Aircraft Waste Streams

Waste Term	Operational Definition	Material Scope	Primary Regulatory Focus
Aviation Food Waste	Edible food and beverage items that remain unused, partially consumed, or discarded following flight operations (McIlwee, 2026).	Unconsumed meal trays, unused galley stock, perishable ingredients, beverage leftovers (Halizahari et al., 2021).	Food waste reduction, resource recovery, and organic waste management (Chen & Hidalgo, 2022).
Catering Waste	Total waste stream generated through onboard food and beverage service provisions (IATA, 2024b).	Food waste combined with packaging materials, single-use plastics, aluminium cans, and service items (Blanca-Alcubilla et al., 2019).	International Catering Waste (ICW) biosecurity regulations (ICAO, 2022; MPI, 2025).
Cleaning Waste	General cabin refuse collected from passenger seating areas during turnaround (Hwang et al., 2023).	Newspapers, magazines, paper towels, tissues, food remnants, and other passenger litter collected from cabin seating areas (IATA, 2019).	Standard cabin turnaround cleaning and municipal waste management (IATA, 2019).

(Source: Author's own, adapted from IATA, 2024b; McIlwee, 2026; MPI, 2025)

When catering waste originates from international flight operations, it may be classified as international catering waste (ICW) because of the potential biological and biosecurity risks associated with food and other catering materials entering another country (IATA, 2024b; ICAO, 2022).

2.2.2 The Scale of Airline Food Waste

The scale of airline food waste has increased in importance alongside the continued growth of global air travel and the expansion of international airline operations (Airports Council International, 2025; Dube et al., 2021). Food and beverage waste represents a substantial component of airline catering waste and is recognised as a significant sustainability challenge for the aviation industry (Blanca-Alcubilla et al., 2019).

Global air passenger traffic recovered strongly following the COVID-19 pandemic and was projected to reach approximately 9.5 billion passengers in 2024 (Airports Council International, 2025; Dube et al., 2021). Passenger numbers are forecast to exceed 12 billion by 2030 and reach 19.5 billion by 2042, with global traffic expected to increase to 244% of 2019 levels by 2050 (Airports Council International, 2025). This continued growth is expected to generate larger volumes of airline catering waste, particularly on long-haul international routes where multiple meal services are provided (Blanca-Alcubilla et al., 2019; IATA, 2024b).

Earlier industry estimates suggested that commercial aviation generated approximately 5.7 million tonnes of cabin waste annually (IATA, 2019). More recent IATA cabin waste audits estimated approximately 3.6 million tonnes of cabin and catering waste in 2023, with around 65% consisting of food and beverage waste (IATA, 2024b). These estimates demonstrate the substantial volume of waste associated with airline operations and the significant contribution of food and beverage waste to the overall waste stream. As international aviation continues to expand, effective management of this waste will become increasingly important for reducing disposal requirements, operational costs, and environmental impacts (Chen & Hidalgo, 2022; Dube et al., 2021).

2.2.3 Causes of Airline Food Waste

Airline food waste is generated through a combination of operational, behavioural, logistical, and regulatory factors that interact throughout the airline catering process (Halizahari et al., 2021; You et al., 2020). One of the primary causes is operational uncertainty associated with forecasting passenger demand, which often results in airlines over-catering flights to minimise the risk of meal shortages and maintain service quality (Jainudeen Nawas, 2025; Li, 2024). Airlines routinely load surplus meals to accommodate fluctuations in passenger numbers, changing meal preferences, seat upgrades, and operational disruptions, prioritising customer satisfaction over waste minimisation (Jainudeen Nawas, 2025; You et al., 2020).

Passenger behaviour also contributes significantly to the generation of airline food waste. Meal preferences, eating habits, dissatisfaction with menu choices, and physiological changes in taste perception caused by cabin pressure can result in meals being only partially consumed or left untouched (Halizahari et al., 2021; You et al., 2020). In addition, long-haul flights require multiple meal services and extended food storage, increasing the likelihood of overproduction, spoilage, and surplus food generation (Blanca-Alcubilla et al., 2019). These operational requirements make it difficult for airlines to accurately match catering supply with passenger demand.

Logistical challenges throughout the airline catering supply chain further contribute to food waste. Tight catering schedules, transportation delays, poor coordination between catering providers and airlines, and limited onboard waste-segregation facilities reduce opportunities to minimise waste before, during, and after flights (Li, 2024; Rajaratnam, 2023). The widespread use of disposable service items and non-reusable packaging materials further increases the overall volume of catering waste generated during airline operations (Li, 2024).

Regulatory requirements also influence how airlines manage surplus food and catering waste. International food safety and biosecurity requirements can restrict opportunities for the reuse or redistribution of unconsumed meals, particularly within international airline operations (IATA, 2024a; Li, 2024). These requirements can therefore reduce the range of recovery or redistribution options available for surplus food once it enters the international catering system (IATA, 2024a; Li, 2024). Collectively, these operational, behavioural, logistical, and regulatory factors make reducing airline food waste particularly challenging and reinforce the need for more sustainable food waste management strategies within commercial aviation (Halizahari et al., 2021; Li, 2024).

2.2.4 Environmental Impacts of Airline Food Waste

The generation of aviation food waste carries significant environmental consequences because discarded food represents the loss of resources invested throughout food production, processing, packaging, transportation, cold-chain storage, and onboard preparation (Nakornkao & Mongkalig, 2022; Wright, 2019). When in-flight food is discarded, the water, energy, fuel, labour, and raw materials used in its production and distribution throughout the food supply chain are also wasted, resulting in unnecessary greenhouse gas emissions and inefficient resource utilisation (Nakornkao & Mongkalig, 2022; Salesa et al., 2023). Consequently, reducing food waste is recognised as an important goal for improving environmental sustainability within the aviation industry.

The disposal of aviation food waste further contributes to environmental degradation. Organic food waste disposed of in landfills undergoes anaerobic decomposition, producing methane, a greenhouse gas with a substantially greater global warming potential than carbon dioxide (Meegoda et al., 2025; Wright, 2019). Alternatively, incineration generates carbon emissions while destroying valuable organic

materials that could otherwise be recovered or reused (Pennington et al., 2025; Wright, 2019). These disposal methods increase the environmental footprint of airline catering operations while reducing the potential for sustainable waste management.

In addition to food waste, airline catering operations generate considerable quantities of single-use plastic trays, cutlery, cups, wrappers, and other packaging materials (Blanca-Alcubilla et al., 2019; Salesa et al., 2023). These materials frequently become contaminated with food waste, reducing their recyclability and increasing the volume of waste requiring controlled disposal (Blanca-Alcubilla et al., 2019). Collectively, these environmental impacts highlight the need for more sustainable catering practices, improved waste prevention strategies, and innovative waste management solutions. In response to these environmental challenges, airlines have increasingly adopted waste reduction, material efficiency, and other Circular Economy practices to improve the environmental performance of their operations (Salesa et al., 2023).

2.3 Sustainability Practices in Aviation

The aviation industry has significant environmental impacts due to its contribution to greenhouse gas emissions, resource consumption, and climate change, creating increasing pressure to adopt more sustainable operational practices (Leal Filho et al., 2023). Although national and international initiatives have been introduced to reduce aviation's environmental impact, much of the existing research and industry focus has centred on carbon emissions, fuel efficiency, and carbon-neutral growth (Abrantes et al., 2021; Amicarelli et al., 2021). Consequently, airlines have prioritised strategies such as fleet modernisation, improvements in fuel efficiency, and the adoption of sustainable aviation fuels (SAFs) to reduce their environmental footprint (Abrantes et al., 2021).

More recently, sustainability initiatives within the aviation industry have expanded beyond carbon reduction to include resource efficiency, waste minimisation, and more sustainable catering operations (Baxter et al., 2021; Salesa et al., 2023). This broader approach is particularly relevant to airline catering, where reducing food and material waste can improve resource utilisation while reducing the environmental impacts associated with waste generation and disposal. These developments demonstrate that waste management is increasingly connected to wider aviation sustainability efforts rather than being treated solely as an operational disposal issue. Accordingly, this section examines airline sustainability strategies, waste reduction initiatives, and resource efficiency strategies relevant to improving environmental performance within aviation operations.

2.3.1 Airline Sustainability Strategies

Airline sustainability strategies comprise the policies, initiatives, and operational practices implemented to reduce environmental impacts while improving long-term environmental performance (Abrantes et al., 2021; Guven et al., 2024). Within the broader shift towards sustainable aviation, these strategies

increasingly extend beyond carbon reduction to include waste minimisation, resource efficiency, operational improvements, and Circular Economy practices (Guven et al., 2024; Salesa et al., 2023). This broader approach demonstrates how environmental sustainability is becoming integrated across different areas of airline operations.

Many airlines have incorporated sustainability objectives into their corporate strategies through environmental targets and operational initiatives (Abrantes et al., 2021). For example, China Southern Airlines (2025) has reported sustainability indicators across its operations, including waste reduction, fuel efficiency improvements, and environmentally responsible operational practices. Similarly, Air New Zealand (2025b) and Qantas Group (2025) have reported sustainability programmes that incorporate carbon reduction, waste minimisation, resource efficiency, and responsible environmental management. These examples illustrate how broader sustainability objectives are being translated into organisational and operational initiatives within the airline industry.

Technological innovation has also become an important component of airline sustainability strategies. Airlines are increasingly adopting digital meal forecasting systems, predictive analytics, and artificial intelligence (AI) to improve catering operations, reduce over-catering, and minimise in-flight food waste (Aghazadeh, 2025). These technologies demonstrate how broader sustainability commitments can be translated into operational practices that target waste at its source. Waste reduction therefore represents an important area in which airline sustainability strategies can be implemented through day-to-day catering operations.

2.3.2 Waste Reduction Initiatives

Airlines have implemented a range of waste reduction initiatives to improve environmental sustainability and reduce the operational impacts associated with in-flight catering waste. One important approach has been the adoption of improved catering management systems that utilise passenger data, demand forecasting, and predictive analytics to optimise meal loading and minimise over-catering (Jainudeen Nawas, 2025).

Alongside efforts to prevent food waste at its source, waste segregation and recycling programmes have become important components of airline waste management strategies. Airlines have introduced systems to separate recyclable materials, including paper, plastics, and aluminium, from general cabin waste to improve opportunities for recycling and reduce landfill disposal (Baxter et al., 2021). In addition, recyclable, biodegradable, or reusable alternatives are increasingly being considered to reduce reliance on conventional single-use catering materials (Kiriş & Gürül, 2024). Sustainable packaging and lightweight catering equipment can further reduce material consumption while contributing to lower aircraft weight and associated fuel consumption (Kiriş & Gürül, 2024).

Beyond airline operations, airports also play an important role in supporting waste reduction initiatives. For example, Auckland Airport has established a target of diverting 90% of its operational waste from landfill and has implemented programmes such as food waste composting to support its broader sustainability objectives (Auckland Airport, 2025b). These initiatives demonstrate how collaboration between airports and airlines can contribute to broader sustainability objectives across the aviation sector.

In its annual report, Singapore Airlines (2023) reported a range of sustainability initiatives, including digital meal planning, waste recycling, resource-efficient catering operations, and measures intended to minimise food waste throughout its onboard service. These initiatives illustrate how waste prevention, recycling, and resource efficiency can operate together as part of a broader approach to reducing catering waste. Collectively, these practices demonstrate that reducing airline catering waste involves both preventing unnecessary food and material use at the source and improving the management of waste that cannot be avoided. This increasing emphasis on prevention also highlights the importance of using materials and other operational resources more efficiently throughout airline catering operations.

2.3.3 Resource Efficiency Strategies

Resource efficiency is an important component of aviation sustainability, focusing on the optimisation of materials, energy, food, and operational resources while minimising waste and environmental impacts (Calvet, 2024). Building on waste-reduction initiatives, airlines are increasingly adopting resource-efficient practices to improve environmental performance and reduce operating costs. Within catering operations, improved inventory management and digital demand planning can support more efficient use of food resources by better aligning catering supply with passenger demand (Rajaratnam, 2023).

Resource efficiency also extends beyond food to the materials, energy, and water used throughout airline and catering operations. Lightweight catering products can reduce aircraft weight and associated fuel consumption, while recyclable and reusable service items can improve opportunities for material recovery (Baxter et al., 2021; Jacob et al., 2025). Sustainable supply chain management, energy-efficient catering facilities, and water conservation initiatives further demonstrate how resource efficiency can be incorporated across airline operations (Karvounidi et al., 2024). However, the ability to implement these sustainability practices consistently is influenced by operational, infrastructural, and regulatory conditions within the aviation system.

2.3.4 Limitations of Current Sustainability Approaches

Despite growing commitments to sustainability, airlines continue to face operational and regulatory barriers that limit the implementation of current sustainability initiatives. While aviation sustainability strategies have placed considerable emphasis on carbon reduction through fuel-efficient aircraft and

Sustainable Aviation Fuels (SAFs), waste management and in-flight food waste have received less attention (Abrantes et al., 2021; Gössling & Higham, 2021). In addition, operational constraints, including limited onboard space for waste segregation, tight flight schedules, and inconsistencies in airport recycling infrastructure, can reduce opportunities for effective waste recovery and recycling (Salesa et al., 2023).

Regulatory requirements present an additional challenge to sustainable waste management, particularly for catering waste generated through international airline operations. Food safety and biosecurity requirements can restrict the waste-management options available to airlines and complicate the implementation of practices such as reuse, recycling, composting, and resource recovery (Hetherington, 2019; Tjahjono et al., 2023). These regulatory constraints demonstrate that airline sustainability initiatives cannot be implemented independently of the wider regulatory environment in which international aviation operates.

Although airlines continue to strengthen their sustainability commitments, achieving more comprehensive approaches to food waste management remains challenging because environmental objectives must be balanced with operational and regulatory requirements (Salesa et al., 2023; Tjahjono et al., 2023). These limitations indicate that sustainable airline food waste management requires an approach that considers not only how waste is treated after it is generated, but also how waste can be prevented and resources retained in use for longer. This has led to increasing interest in Circular Economy as a framework for waste prevention, resource efficiency, reuse, recycling, and resource recovery within the aviation industry.

2.4 Circular Economy Framework

The Circular Economy (CE) is a sustainability framework that aims to minimise waste, maximise resource efficiency, and promote the reuse, recycling, and recovery of materials throughout production and consumption systems (Kirchherr et al., 2017). Unlike the traditional linear take–make–dispose model, the Circular Economy seeks to keep resources in use for as long as possible while reducing waste generation and environmental impacts (Geissdoerfer et al., 2020). In this study, Circular Economy refers to the broader sustainability concept, while the term Circular Economy framework refers specifically to its use as the theoretical framework guiding the analysis. Circular Economy principles refer to the individual principles within this framework, including waste prevention, resource efficiency, reuse, recycling, and resource recovery.

As this study examines the management of International Catering Waste under New Zealand's biosecurity regulations, Circular Economy provides an appropriate theoretical framework for evaluating how airlines seek to minimise waste, improve resource efficiency, and recover value from resources while meeting regulatory requirements. The framework is particularly relevant because it enables the

study to examine both the sustainability practices adopted by airlines and the regulatory conditions that may enable or constrain the application of these practices.

2.4.1 Principles of the Circular Economy

The Circular Economy framework is founded on principles that aim to minimise waste and maximise the efficient use of resources throughout their life cycle (Kirchherr et al., 2017). A fundamental principle is waste prevention, which focuses on reducing waste generation at its source through more efficient production and service processes (Gonçalves & Máximo, 2023). Other key principles include reuse, recycling, refurbishment, and recovery of products and materials to extend their value and reduce dependence on virgin resources (Geissdoerfer et al., 2020).

Within the aviation industry, these principles are reflected in initiatives such as reducing in-flight food waste, improving meal forecasting, recycling catering materials, minimising single-use plastics, and enhancing resource recovery through sustainable catering practices (Salesa et al., 2023). In the context of airline catering, Circular Economy principles therefore provide opportunities to consider the prevention of unnecessary food and material waste alongside downstream options such as recycling and resource recovery. These principles provide a basis for evaluating the extent to which airline food waste management practices move away from conventional disposal towards more circular forms of resource management.

2.4.2 Circular Economy Application in Aviation

Circular Economy principles are increasingly being translated into practical applications within the aviation industry, particularly through initiatives that prioritise waste prevention, resource efficiency, and the retention of material value within operational systems (Salesa et al., 2023). Within airline catering, these applications include more efficient catering processes, reduced use of disposable materials, recycling of cabin and catering materials, and the introduction of alternative materials designed to reduce waste generation (Salesa et al., 2023).

Digital technologies can further support these applications by enabling more accurate catering decisions and reducing unnecessary food and resource use (Aghazadeh, 2025; Swanepoel, 2021). From a Circular Economy perspective, their value lies in supporting waste prevention at the source rather than relying solely on downstream waste treatment.

Circular Economy applications also extend beyond individual airline operations. Partnerships with catering providers and waste management companies can support recycling programmes, material recovery, and more environmentally responsible waste management practices (Salesa et al., 2023). These applications demonstrate how Circular Economy principles can be translated into practical aviation initiatives through waste prevention, resource efficiency, material recovery, and stakeholder

collaboration. However, the extent to which these practices can be implemented within international aviation is influenced by operational, infrastructural, and regulatory constraints.

2.4.3 The Challenge of Implementing Circular Economy Principles in Aviation

Despite its potential to improve resource efficiency and reduce waste, implementing Circular Economy principles within the aviation industry faces several operational and regulatory challenges. Food safety and hygiene requirements can restrict opportunities for the reuse and redistribution of surplus food and catering materials, while the widespread use of disposable service items can limit opportunities for recycling and material recovery (Blanca-Alcubilla et al., 2019; IATA, 2024a). Implementation can also be constrained by the costs associated with introducing new waste management systems, limited waste-segregation infrastructure, and the need to coordinate multiple stakeholders, including airlines, airports, catering providers, and waste management companies (Amicarelli et al., 2021).

Mixed waste streams generated through international airline operations, together with limitations in airport infrastructure, short aircraft turnaround times, and specific waste-handling requirements, can further constrain the application of Circular Economy practices (Papavasileiou, 2020). These challenges demonstrate that implementing Circular Economy principles in aviation depends not only on airline sustainability strategies but also on the operational and regulatory environment in which airlines operate. This is particularly important for international catering waste, where national biosecurity requirements can determine how waste is handled and which management options are available. Understanding these regulatory requirements is therefore necessary for evaluating the practical application of Circular Economy principles within international airline operations.

2.5 Biosecurity and International Catering Waste Regulation

Biosecurity regulations play an important role in the management of ICW generated through international airline operations. According to IATA (2024a), ICW can include food waste, beverages, packaging materials, and other catering waste that may present biological risks when transported across international borders. These risks arise from the potential introduction of pests, pathogens, animal diseases, and other biological materials that could affect agriculture, biodiversity, and public health. Consequently, countries establish regulatory requirements governing the collection, transportation, treatment, and disposal of ICW to minimise biosecurity risks and protect national ecosystems (ICAO, 2022).

Treatment and disposal requirements vary between regulatory jurisdictions, but ICW may be subject to controlled processes designed to reduce or eliminate potential biosecurity risks before final disposal or further management. In New Zealand, the Ministry for Primary Industries (MPI) regulates international catering waste as biosecurity-risk material and specifies requirements for its handling, treatment, and disposal (MPI, 2025). These requirements directly affect airlines operating international services to

New Zealand because catering waste cannot be managed solely according to environmental sustainability objectives; it must also comply with national biosecurity requirements.

2.5.1 Biosecurity Risk and Border Protection

Biosecurity risk refers to the potential introduction and spread of pests, diseases, invasive species, and harmful microorganisms that may threaten agriculture, biodiversity, ecosystems, and public health (Hulme et al., 2023). International air travel can increase exposure to these risks through the movement of people, food products, and other biological materials across national borders (ICAO, 2022). Consequently, food waste and catering materials arriving through international aviation may present biosecurity risks that require controlled inspection, handling, transportation, treatment, and disposal procedures (Riasari et al., 2021; Świerczyńska, 2023).

These risks are particularly important within the New Zealand context because of the country's geographical isolation, unique biodiversity, and economic dependence on agriculture and primary industries (Stone, 2021). The introduction of invasive pests or diseases can result in significant environmental and economic consequences (Eschen et al., 2021). Consequently, airlines operating international services to New Zealand must comply with applicable biosecurity controls administered by the MPI (MPI, 2025). These controls establish the regulatory conditions within which ICW must be managed after entering New Zealand and provide the basis for understanding the specific requirements examined in the following section.

2.5.2 Regulation of International Catering Waste

The management of ICW is governed by regulatory controls intended to minimise the biosecurity risks associated with food, animal products, plant materials, and other potentially contaminated catering materials that may introduce pests or diseases across national borders (Pennington et al., 2025). Such materials may present biosecurity risks because they can carry pests, pathogens, or other biological contaminants that could be introduced into the destination country. These controls can apply across different stages of the waste-management process, including collection, storage, transportation, treatment, and final disposal. Depending on the regulatory jurisdiction and the nature of the waste, treatment and disposal may involve controlled methods designed to reduce or eliminate potential biosecurity risks (Blanca-Alcubilla et al., 2026).

In New Zealand, ICW is regulated by MPI as biosecurity-risk material to prevent the introduction of pests and diseases that could threaten agriculture and the wider environment (MPI, 2025). Airlines and other organisations involved in handling this waste are therefore required to operate within prescribed biosecurity controls governing its management, treatment, and disposal.

2.5.3 Biosecurity Waste Management Systems in New Zealand

New Zealand maintains a stringent biosecurity system designed to prevent the introduction of pests, diseases, and invasive organisms that could threaten the country's environment, agriculture, and biodiversity (Meurisse et al., 2023). Under requirements administered by MPI, ICW from inbound international flights is managed as biosecurity-risk material and is subject to controlled handling procedures covering its collection, transportation, storage, treatment, and disposal (MPI, 2025). These requirements ensure that waste presenting potential biosecurity risks is managed through approved processes before final disposal or further treatment.

At Auckland Airport, ICW is managed separately from domestic waste through dedicated airside collection systems, approved waste facilities, and authorised contractors (Auckland Airport, 2025b). This controlled system ensures that ICW remains segregated and is directed through approved treatment and disposal pathways in accordance with New Zealand's biosecurity requirements (Auckland Airport, 2025b; MPI, 2025). This demonstrates how national biosecurity requirements are translated into operational waste-management procedures at the airport level. However, these controls also influence the range of waste-management options available to airlines and other stakeholders. While this section has established how ICW is regulated and managed within New Zealand's biosecurity system, the following section examines how these regulatory requirements affect the implementation of sustainable waste management and Circular Economy practices within international airline operations.

2.6 Regulatory Constraints on Sustainable Waste Practices in New Zealand

New Zealand's biosecurity requirements create significant constraints for implementing sustainable waste management practices within international airline operations (MPI, 2025; Pennington et al., 2025). ICW generated through inbound international flights is subject to controlled handling, treatment, and disposal requirements intended to minimise the risk of introducing pests, diseases, and other biosecurity threats (MPI, 2025). While these requirements serve an important border-protection function, they can restrict the range of waste-management options available once catering waste enters New Zealand's biosecurity system. In particular, opportunities for practices such as recycling, composting, food redistribution, and resource recovery may be limited by the regulatory controls governing ICW (IATA, 2024a; ICAO, 2022; Pennington et al., 2025). This creates a tension between mandatory biosecurity compliance and the Circular Economy objective of retaining resources in use and recovering value from waste (Geissdoerfer et al., 2020; Kirchherr et al., 2017).

2.6.1 Biosecurity Regulations in New Zealand and Circular Economy Principles

Circular Economy principles emphasise waste prevention, reuse, recycling, and resource recovery as approaches to retaining the value of resources and reducing environmental impacts (Kirchherr et al., 2017). Within airline catering, these principles can be reflected in practices such as reducing surplus

food, recovering recyclable catering materials, and identifying opportunities to divert organic waste from disposal. However, their application to ICW in New Zealand must operate within the country's biosecurity requirements (MPI, 2025; Pennington et al., 2025).

This creates an important tension between Circular Economy objectives and biosecurity compliance. While Circular Economy approaches seek to retain resources within productive use and reduce reliance on final disposal, New Zealand's biosecurity controls prioritise the prevention of pests and diseases entering the country and the protection of agriculture and biodiversity (MPI, 2025; Stone, 2021). Consequently, the feasibility of recycling, composting, reuse, or other forms of resource recovery depends on whether these practices can be undertaken within applicable biosecurity requirements. For international airlines, sustainable catering waste management therefore requires Circular Economy objectives to be pursued within, rather than independently of, the regulatory framework.

2.6.2 Operational Implications for Airlines Operating in New Zealand

New Zealand's biosecurity requirements have operational implications for airlines operating international services to the country. Airlines must ensure that ICW is managed in accordance with MPI requirements governing its handling, storage, transportation, treatment, and disposal (MPI, 2025). Compliance therefore extends beyond the aircraft itself and requires coordination between airlines, airports, catering providers, authorised waste handlers, and other organisations involved in the management of ICW (IATA, 2024a; ICAO, 2022).

These requirements can also influence the waste-management options available after ICW has entered the New Zealand biosecurity system. For airlines seeking to improve environmental performance, waste segregation, recycling, composting, and resource recovery options must therefore be evaluated within applicable biosecurity requirements (IATA, 2024a; MPI, 2025). This reinforces the importance of coordination between operational and regulatory stakeholders when developing more sustainable approaches to ICW management.

Airline catering operations must also balance waste reduction with operational efficiency and passenger service requirements. Long-haul operations can involve uncertainty in passenger demand and meal preferences, which may contribute to surplus meal loading and increase the likelihood of food waste (Li, 2024). These operational pressures, combined with the regulatory requirements governing ICW, mean that sustainable food waste management requires both preventing waste before it is generated and managing unavoidable waste within established biosecurity controls.

2.7 Research Gap

Research on aviation sustainability has predominantly concentrated on carbon-related environmental impacts, including fuel-efficiency improvements and the adoption of Sustainable Aviation Fuels

(SAFs), whereas the management of in-flight food and catering waste has received less attention (Abrantes et al., 2021).

A review of the academic literature revealed that the research problem is situated within several interconnected fields of scholarship, including global tourism, environmental sustainability, the Circular Economy, food waste management, and aviation. Research on global tourism and mobility has examined the environmental consequences of increasing international travel and the challenges associated with sustainable tourism development (Dube et al., 2021; Gössling & Higham, 2021; Hall, 2011). Within sustainability scholarship, Circular Economy research has established the importance of moving beyond linear resource consumption towards waste prevention, resource efficiency, and material recovery, while also recognising the practical limitations of circular systems (Blomsma & Brennan, 2017; Geissdoerfer et al., 2020; Kirchherr et al., 2017; Korhonen et al., 2018). Food waste scholarship has further examined the operational, behavioural, and organisational factors contributing to waste generation across food-service and hospitality contexts (Dhir et al., 2020; Filimonau & De Coteau, 2019). In aviation, research has investigated cabin waste composition, airline catering practices, and opportunities for improved waste management (Blanca-Alcubilla et al., 2019; Salesa et al., 2023; You et al., 2020). However, despite these contributions, limited academic attention has been directed towards integrating these perspectives to explain how international airline food waste management can align with Circular Economy objectives while operating under destination-specific biosecurity regulations, particularly in New Zealand.

Previous studies have examined airline food waste and its environmental impacts (Li, 2024; You et al., 2020), the application of Circular Economy principles within aviation (Amicarelli et al., 2021; Salesa et al., 2023), and the challenges associated with managing ICW within biosecurity and regulatory environments (Pennington et al., 2025). Regulatory and industry guidance further establishes the specific controls governing ICW within international aviation and the New Zealand context (IATA, 2024a; MPI, 2025). However, these areas of research have largely developed separately, leaving limited understanding of how airline food waste management can simultaneously address sustainability objectives, Circular Economy principles, and mandatory biosecurity requirements. In particular, the literature reviewed for this study identified limited comparative research examining how airlines operating direct international services to Auckland manage in-flight food waste within New Zealand's biosecurity framework.

This study addresses this gap by comparatively examining the food waste management practices of five major airlines operating direct flights to Auckland. It investigates how sustainability objectives and Circular Economy principles interact with New Zealand's biosecurity requirements, with particular attention to the challenges and opportunities that arise when sustainable food waste management is pursued within a highly regulated aviation environment.

2.8 Chapter Summary

This chapter critically reviewed the literature on in-flight food waste management, aviation sustainability, the Circular Economy, and the biosecurity regulations governing ICW. The review established that in-flight food waste represents an important environmental and operational challenge influenced by operational, behavioural, logistical, and regulatory factors. It also demonstrated that although airline sustainability efforts have expanded beyond carbon reduction to include waste minimisation and resource efficiency, the implementation of sustainable waste management practices continues to be influenced by operational and regulatory conditions.

The chapter further examined the Circular Economy framework underpinning this study and considered how its principles can be applied within the aviation industry. Circular Economy principles provide opportunities for waste prevention, resource efficiency, reuse, recycling, and resource recovery. However, their application to ICW is restricted by New Zealand's biosecurity requirements, which regulate how potentially risk-bearing materials are managed. This creates an important tension between the pursuit of greater circularity and the need to maintain mandatory biosecurity protection.

Finally, the literature review identified limited research examining how airlines operating direct international services to Auckland manage in-flight food waste while pursuing sustainability and Circular Economy objectives within New Zealand's biosecurity framework. Addressing this gap provides the rationale for the present study and establishes the foundation for the research methodology presented in Chapter 3.

Chapter 3: Methodology

3.1 Introduction

Methodology provides the theoretical framework that guides how research is designed, conducted, and interpreted. It ensures that methodological decisions are aligned with the research aim and research questions and provides the rationale for selecting appropriate research methods (Creswell & Poth, 2018; Saunders et al., 2023). Accordingly, this chapter explains and justifies the methodological choices adopted to investigate the in-flight food waste management practices of major airlines operating direct international services to Auckland within New Zealand's biosecurity regulatory environment.

The chapter presents the research philosophy, research paradigm, qualitative research approach, comparative case study design, case selection and sampling strategy, document data collection, and data analysis procedures. It also discusses the processes used to enhance the trustworthiness of the research, ethical considerations, and methodological limitations. Figure 3.1 provides an overview of the methodological process adopted in this study. The research followed an interpretivist philosophy and a qualitative comparative multiple-case study design (Creswell & Poth, 2018; Yin, 2018). Documentary data were analysed using hybrid thematic analysis supported by NVivo 15.4 software (Braun & Clarke, 2022; Fereday & Muir-Cochrane, 2006).

This study relied exclusively on publicly available documentary data and did not involve human participants, interviews, surveys, or the collection of personal information. Ethical considerations therefore focused on the responsible use, interpretation, and reporting of publicly available documentary evidence. The documentary sources were analysed and reported with appropriate attribution to maintain transparency and academic integrity.

Researcher positionality acknowledges that a researcher's professional background and prior experiences may influence how a research topic is approached and interpreted. In this study, the researcher has seven years of professional experience as a Cabin Supervisor with Qatar Airways, involving responsibility for in-flight food and beverage service, service standards, cabin operations, and interactions with airline catering processes. This professional experience provided contextual understanding of airline catering operations and the operational challenges associated with in-flight food service. At the same time, the researcher recognised that this prior experience could influence assumptions and interpretations during the research process. Researcher reflexivity was therefore maintained throughout the analysis by grounding interpretations in the documentary evidence and applying a systematic coding and comparative analytical process (Nowell et al., 2017).

Figure 3.1 Research Process Flow Diagram

Phase 1: Context and Foundations	**Phase 2: Design and Data Collection**	**Phase 3: Qualitative Analysis**	**Phase 4: Synthesis and Output**
Research Problem Literature Review Interpretivist Philosophy	Qualitative Comparative Multiple-Case Study Design Purposive Selection of Airlines Document Collection and Screening	NVivo Data Management Deductive Coding (Parent Nodes) Inductive Coding (Child Nodes)	Theme Development Cross-Case Comparison Findings and Discussion

3.2 Research Philosophy

Research philosophy provides the theoretical foundation that guides how knowledge is understood, generated, and interpreted throughout a research study (Saunders et al., 2023; Tamminen & Poucher, 2020). It reflects the researcher's assumptions about the nature of reality and how knowledge can be developed to address a research problem, thereby informing the methodological decisions adopted in the study (Creswell & Poth, 2018; Crotty, 1998).

This study adopts an interpretivist research philosophy. Interpretivism assumes that reality is socially constructed and that knowledge is developed through interpreting meanings and perspectives within their specific social and organisational contexts (Creswell & Poth, 2018; Crotty, 1998). Rather than seeking a single objective reality, interpretivism acknowledges that organisational practices and decision-making are shaped by contextual influences and multiple perspectives (Pervin & Mokhtar, 2022; Saunders et al., 2023).

An interpretivist philosophy was considered appropriate for this study because it seeks to interpret organisational sustainability practices, regulatory responses, and food waste management strategies of major airlines operating direct international services to Auckland within New Zealand's biosecurity regulatory environment, rather than measure relationships between variables or test statistical hypotheses (Creswell & Poth, 2018; Saunders et al., 2023). The following section discusses the research paradigm adopted to guide the study’s overall design.

3.3 Research Paradigm

A research paradigm provides the overarching framework that guides how a study is designed, conducted, and interpreted by shaping the researcher's assumptions about knowledge and informing the selection of appropriate methodological approaches (Khatri, 2020; Saunders et al., 2023). Four paradigms are commonly recognised in social science research: positivism, interpretivism, critical theory, and pragmatism (Paudel, 2024).

Positivism assumes that reality is objective and can be measured through empirical observation, hypothesis testing, and quantitative methods (Ali, 2024). Interpretivism assumes that reality is socially constructed and seeks to understand meanings, experiences, and contextual interpretations from the perspective of those involved (Pervin & Mokhtar, 2022). Critical theory focuses on examining social structures, power relationships, and inequalities to promote critical reflection and social change (Collins et al., 2021). Pragmatism advocates selecting research methods according to the research problem, often combining qualitative and quantitative approaches to produce practical solutions (Kelly & Cordeiro, 2020).

This study adopts the interpretivist paradigm because it is consistent with the interpretivist philosophy underpinning the research and provides an appropriate framework for exploring organisational practices within their real-world context. The study seeks to understand how major airlines operating direct international services to Auckland manage in-flight food waste while responding to New Zealand's biosecurity requirements. Rather than producing statistically generalisable findings, the research aims to develop a contextual understanding of organisational sustainability practices, operational responses, and regulatory compliance (Creswell & Poth, 2018; Crotty, 1998).

Critical realism was also considered as an alternative research paradigm because it recognises that organisational practices are influenced by underlying structures and mechanisms, including regulatory and institutional conditions (Saunders et al., 2023). This perspective would be relevant to examining how New Zealand's biosecurity requirements influence airline food waste management. However, interpretivism was selected because the primary aim of this study was to understand and interpret how airlines present their sustainability practices, operational responses, and approaches to regulatory compliance through documentary evidence, rather than to identify or explain underlying causal mechanisms. The interpretivist paradigm therefore provides a more appropriate foundation for examining the meanings and organisational perspectives reflected in the selected documents and comparing these across the five airline cases.

The interpretivist paradigm therefore informs the methodological decisions adopted throughout this research by supporting an in-depth interpretation of organisational practices and their regulatory and operational contexts. It provides the foundation for the qualitative research approach presented in the following section, which is considered the most appropriate for addressing the research aim and research questions (Creswell & Poth, 2018; Saunders et al., 2023).

3.4 Research Approach

A research approach provides the overall strategy for collecting and analysing data to address a research problem and achieve the research aim (Saunders et al., 2023). The two principal research approaches are quantitative and qualitative, each differing in their purpose, methods, and the type of knowledge

they generate (Creswell & Poth, 2018). Quantitative research focuses on measuring variables, testing hypotheses, and producing statistically generalisable findings through numerical data and statistical analysis (Almusaed et al., 2025). In contrast, qualitative research seeks to understand meanings, organisational practices, contextual processes, and complex social phenomena within their real-world contexts (Acharya, 2025; Creswell & Poth, 2018).

A qualitative research approach was adopted because this study seeks to understand how major airlines operating direct international services to Auckland manage in-flight food waste within New Zealand's biosecurity regulatory environment. The research explores organisational sustainability practices, food waste management strategies, and regulatory responses through documentary evidence. As the study seeks contextual understanding and interpretation rather than measuring food waste volumes, testing causal relationships, or producing statistically generalisable findings, a qualitative approach was considered the most appropriate (Creswell & Poth, 2018; Crotty, 1998). The qualitative approach therefore provides an appropriate foundation for the comparative case study design adopted in this research, which is discussed in the following section.

3.5 Research Design

Research design refers to the overall framework for conducting a study by linking the research aim with the methods used to collect, analyse, and interpret data (Saunders et al., 2023). Within qualitative research, a case study design enables an investigation of a contemporary phenomenon within its real-world context, particularly where the boundaries between the phenomenon and its context are not clearly defined (Cleland et al., 2021; Yin, 2018).

This study adopted a qualitative comparative multiple-case study design to examine and compare the in-flight food waste management practices of major airlines operating direct international services to Auckland. Comparative case studies enable similarities and differences between multiple organisations to be examined systematically while considering the influence of a shared operational and regulatory context (Goodrick, 2014; Yin, 2018). The selected airlines all operated direct international services to Auckland and were therefore subject to the same New Zealand biosecurity requirements administered by MPI. This shared regulatory context allowed the study to compare organisational approaches to in-flight food waste management while minimising variation arising from different national regulatory environments. The design was therefore appropriate for examining how airlines responded to common sustainability challenges and managed in-flight food waste within New Zealand's biosecurity framework (Goodrick, 2014; Yin, 2018).

3.6 Population

Population refers to the broader group of organisations, settings, or cases from which data relevant to the research can be obtained (Saunders et al., 2023). In qualitative case study research, clearly defining

the population and establishing the boundaries of the study are essential to ensure that the investigation remains focused and aligned with the research aim (Viera, 2023; Yin, 2018).

The population for this study comprised airlines operating scheduled direct international passenger services to Auckland during the study period. Auckland Airport was selected because it is New Zealand's primary international gateway and handles a substantial proportion of the country's international passenger movements (Auckland Airport, 2024b). Auckland Airport reported that, in the financial year 2025 (FY25), 28 airlines served the airport, connecting Auckland with 42 international and 23 domestic destinations (Auckland Airport, 2025a).

The case study was bounded by two parameters. First, it focused exclusively on airlines operating direct international services to Auckland during the study period, ensuring that the selected cases were relevant to the research problem of managing in-flight food waste associated with international airline operations. Second, the study was limited to the New Zealand regulatory environment governing ICW, where the selected airlines were required to comply with biosecurity requirements administered by MPI (MPI, 2025). Establishing these boundaries ensured that differences between the airlines were examined within a common regulatory context, making the cases suitable for comparison (Yin, 2018).

3.7 Sampling

Sampling is the process of selecting cases that are most appropriate for addressing the research aim and research questions (Saunders et al., 2023). In qualitative research, purposive sampling involves deliberately selecting information-rich cases based on characteristics relevant to the phenomenon under investigation, rather than seeking statistical representativeness (Creswell & Poth, 2018; Saunders et al., 2023).

This study adopted a purposive sampling strategy to select five airlines from those operating scheduled direct international passenger services to Auckland during the study period. Airlines were eligible for selection if they operated scheduled direct international passenger services to Auckland and published sufficient documentary evidence relating to sustainability, environmental management, or food waste management to address the research aim and research questions. Airlines that did not operate direct services to Auckland or did not provide sufficient relevant documentary evidence through publicly accessible sources were excluded.

The resulting sample comprised airlines from different geographical regions, including Oceania, Australia, Southeast Asia, East Asia, and the Middle East, and represented different organisational contexts, including variations in airline size, operational characteristics, and sustainability approaches. All selected airlines operated within the same New Zealand biosecurity regulatory environment when providing international services to Auckland. Applying these criteria ensured that the selected cases

were directly relevant to the research aim and suitable for comparative analysis (Saunders et al., 2023; Yin, 2018).

Table 3.1 Airline Selection Justification

Airline	Geographic Region	Direct Flights to Auckland	Sustainability Focus	Relevance to Study
Air New Zealand	New Zealand	Yes	National sustainability leader	Domestic benchmark operating under NZ regulations
Qantas	Australia	Yes	Waste reduction and circularity initiatives	Trans-Tasman comparison under similar regional conditions
Emirates	Middle East	Yes	Large-scale catering and waste management programmes	Represents long-haul international operations
Singapore Airlines	Southeast Asia	Yes	Resource efficiency and sustainability innovation	Strong sustainability reporting practices
China Southern	East Asia	Yes	Environmental and operational sustainability initiatives	Represents the rapidly growing Asian aviation sector

Source: Author's own

3.8 Data Collection

Data collection refers to the systematic process of gathering information to address the research aim and answer the research questions (Saunders et al., 2023). Data may be collected from primary or secondary sources. Primary data are collected directly by the researcher through methods such as interviews, surveys, focus groups, or observations, whereas secondary data consist of existing information originally produced for purposes other than the current study, including organisational reports, government publications, policy documents, and industry reports (Creswell & Poth, 2018; Saunders et al., 2023).

This study relied exclusively on secondary documentary data because the research sought to examine organisational food waste management practices, sustainability initiatives, and regulatory requirements that were already publicly documented. A documentary approach was considered appropriate because it enabled the systematic examination and comparison of official organisational, regulatory, and industry information relevant to the research aim (Bowen, 2009; Saunders et al., 2023).

Documents were included if they were publicly available, directly related to airline sustainability, food waste management, ICW, or New Zealand biosecurity regulations, and contained sufficient information to examine how the airlines manage in-flight food waste while balancing sustainability objectives, Circular Economy principles, and New Zealand's biosecurity requirements. Documents that did not

address these topics or did not provide information relevant to this aim were excluded from the analysis (Bowen, 2009; Saunders et al., 2023).

A total of 16 publicly available documents were collected and imported into NVivo 15.4 for analysis. The documentary dataset comprised three airline sustainability reports, two airline annual reports, two Auckland Airport documents, one catering company annual report, three government and biosecurity documents, four industry publications, and one policy document (see Table 3.2). These documents were organised into separate source categories within NVivo to facilitate systematic coding, data management, and comparative analysis.

Table 3.2 Documentary Data Source

Document Category	Source	No. of Documents	Purpose
Airline sustainability reports	China Southern, Qantas Airline Singapore Airlines	3	Examine sustainability strategies, food waste management and environmental initiatives.
Airline annual reports	Air New Zealand, Emirates	2	Examine organisational priorities, governance and operational sustainability.
Catering company annual report	Gate Gourmet	1	Examine airline catering operations and food service practices.
Airport documents	Auckland Airport	2	Examine airport sustainability initiatives and operational procedures relating to ICW.
Government and biosecurity documents	Ministry for Primary Industries (MPI)	3	Examine New Zealand biosecurity requirements governing ICW.
Industry publications	International Air Transport Association (IATA) and International Civil Aviation Organisation ICAO	4	Examine international guidance on airline food waste management and sustainability.
Policy document	Trans-Tasman Arrangement	1	Provide policy context relevant to international aviation and biosecurity.
Total		16	

3.9 Data Analysis

Data analysis is the systematic process of organising, coding, and interpreting qualitative data to identify meaningful patterns that address the research aim and research questions (Saunders et al., 2023). This study employed thematic analysis to systematically examine the secondary documentary data collected from airline sustainability reports, annual reports, government and biosecurity documents, airport publications, industry reports, and policy documents. Thematic analysis was selected because it provides a systematic yet flexible approach for identifying, organising, and interpreting recurring patterns across qualitative datasets (Ahmed et al., 2025; Braun & Clarke, 2021). Consistent with the qualitative comparative multiple-case study design adopted in this research, the analysis was conducted

through both within-case and cross-case analysis to identify organisation-specific practices and broader patterns across the selected airline cases (Yin, 2018). The overall data analysis process adopted in this study is summarised in Table 3.3, and each stage of the analytical procedure is explained in the following subsections.

3.9.1 Analytical Approach

Thematic analysis was adopted as the analytical approach for this study because it enables researchers to systematically identify, organise, and interpret patterns of meaning across qualitative datasets (Ahmed et al., 2025; Braun & Clarke, 2021). This approach was considered appropriate because the study sought to interpret organisational practices, sustainability initiatives, and regulatory requirements relating to in-flight food waste management through documentary evidence. Thematic analysis also aligns with the interpretivist research philosophy by facilitating the interpretation of meanings embedded within qualitative data (Creswell & Poth, 2018).

To support the analytical process, NVivo 15.4, a Computer-Assisted Qualitative Data Analysis Software (CAQDAS), was used to organise, manage, code, and retrieve qualitative data systematically (Jackson & Bazeley, 2019). CAQDAS enables researchers to efficiently organise documentary evidence, manage coding, retrieve coded extracts, and maintain a transparent audit trail throughout the analytical process (Allsop et al., 2022; Jackson & Bazeley, 2019). Manual coding, which involves assigning and organising codes without the use of specialised qualitative analysis software, was also considered. However, it was not adopted because the study involved a substantial documentary dataset comprising sixteen documents from multiple organisational, regulatory, airport, and industry sources, making systematic coding, retrieval, and comparison more efficient and consistent using NVivo software (Jackson & Bazeley, 2019). Nevertheless, NVivo functioned only as an analytical support tool, while the interpretation of the data, refinement of the coding framework, and development of themes remained the responsibility of the researcher (Allsop et al., 2022).

A hybrid coding approach, combining deductive and inductive coding, was adopted because it allowed the analysis to be informed by existing theoretical knowledge while remaining open to new insights emerging from the documentary evidence (Braun & Clarke, 2021; Kaur et al., 2025). This approach enabled the coding framework to remain conceptually grounded in the literature while retaining sufficient flexibility to capture organisational practices and operational issues specific to the selected airline cases.

3.9.2 Systematic Coding Procedure

The systematic coding procedure commenced with document familiarisation, whereby all sixteen documentary sources were read repeatedly to develop a comprehensive understanding of their content, context, and relevance to the research aim before formal coding began (Bowen, 2009). This process

enabled the researcher to gain an overall understanding of the documentary evidence relating to in-flight food waste management, sustainability initiatives, Circular Economy practices, and New Zealand's biosecurity requirements. Following familiarisation, all selected documents were imported into NVivo 15.4 and organised according to their respective source categories to facilitate the systematic management of the documentary dataset throughout the analysis.

The coding process then proceeded through iterative refinement, a cyclical analytical process in which codes are continuously reviewed, compared, revised, and consolidated to improve the coherence and accuracy of the coding framework throughout qualitative analysis (Braun & Clarke, 2021). In this study, the researcher systematically reviewed the coded documentary evidence, merged duplicate and conceptually similar codes, refined existing categories, and created additional child nodes where necessary to ensure that the coding framework accurately reflected the documentary data. Coding was therefore based on the identification and organisation of relevant concepts within the documentary evidence rather than simply the occurrence of individual words. Table 3.3 summarises the systematic coding and analysis process applied to the documentary dataset.

Data saturation refers to the stage in qualitative analysis at which further analysis produces little or no substantively new information, codes, or themes (Guest et al., 2020; Saunders et al., 2018). In this study, the documentary dataset had been predefined through the selection of five airline cases and the relevant documents identified for the comparative case study. Therefore, saturation was not used to determine when data collection should cease; all sixteen documents were analysed regardless of when saturation became apparent. During the earlier stages of analysis, the coding framework continued to develop as additional child codes were created, overlapping codes were merged, and existing categories were refined. As the analysis progressed, each additional document was compared against the developing coding framework to determine whether it introduced new concepts or required changes to the thematic structure. In the later stages of coding, additional documentary evidence was increasingly accommodated within the existing coding framework and primarily strengthened the established themes rather than generating substantively new parent themes. This progressive reduction in new thematic information indicated that the predefined documentary dataset was sufficient to achieve saturation within the analytical framework (Saunders et al., 2018). Nevertheless, all sixteen documents were fully coded to ensure comprehensive and consistent analysis across the complete documentary dataset.

Table 3.3 Data Analysis Process

Stage	Activity	Purpose	Analytical Approach
1. Document Familiarisation	Read and reviewed each selected document several times before coding.	Develop understanding of document content, context and key sustainability issues.	Familiarisation
2. Initial Deductive Coding	Created initial parent nodes in NVivo based on the literature review, research objectives and Circular Economy framework.	Organise documentary evidence using an initial analytical framework.	Deductive Coding
3. Iterative Code Refinement	Reviewed documents in greater depth and created additional child nodes where new concepts emerged.	Refine the coding framework and capture emerging operational practices.	Hybrid Coding (Deductive–Inductive)
4. Theme Development	Grouped related codes into broader analytical themes.	Identify recurring patterns across the documentary dataset.	Thematic Analysis
5. Within-Case and Cross-Case Analysis	Analysed each airline individually before comparing similarities and differences across the five airline cases.	Identify organisation-specific practices and broader industry patterns.	Comparative Case Study Analysis
6. Interpretation and Reporting	Interpreted the final themes against the research objectives, literature and Circular Economy framework before presenting findings	Generate meaningful conclusions and answer the research questions.	Interpretive Analysis

Sources: Author's own, adapted from Braun and Clarke (2021); Yin (2018); Ahmed et al. (2025).

Table 3.4 summarises the documentary sources analysed and the sequence in which they were coded within NVivo 15.4. The coding process followed a structured and iterative approach, beginning with government and biosecurity documents to establish an understanding of New Zealand's regulatory framework governing ICW. Airline reports were then analysed to examine organisational food waste management practices, followed by industry publications to provide broader sector-wide perspectives on sustainability and regulatory guidance. The Gate Gourmet Annual Report 2025 was analysed last to incorporate the catering service provider perspective. Throughout the analysis, the coding framework was continuously reviewed, refined, and consistently applied across all documentary sources by merging conceptually similar codes and clarifying code definitions where necessary. As additional documents were analysed, they primarily reinforced and refined the existing coding framework rather than generating new parent themes. This iterative process resulted in a stable analytical framework comprising eight parent themes and forty-four sub-themes, indicating that sufficient thematic coverage had been achieved across the documentary dataset (Braun & Clarke, 2021; Saunders et al., 2023).

Table 3.4 Documentary Sources, Coding Sequence, and NVivo Coding Summary

Order	Source Category	Documentary Source	Coded References	Coding Outcome
1	Government Reports	Biosecurity Rules New Zealand	132	Initial regulatory framework established.
2	Government Reports	MPI Waste Import Health Standard	62	Biosecurity coding framework refined.
3	Government Reports	Auckland Airport Annual/Sustainability Report	257	Airport operational context incorporated.
4	Government Reports	Auckland Airport Aircraft Waste Management Document	41	Existing regulatory themes reinforced.
5	Government Reports	Trans-Tasman Biosecurity Relations Document	46	Regulatory understanding strengthened.
6	Airline Reports	Air New Zealand Annual Report	92	Organisational practices introduced.
7	Airline Reports	Qantas Sustainability Report	193	Comparative airline evidence expanded.
8	Airline Reports	Singapore Airlines Sustainability Report	255	Existing framework reinforced.
9	Airline Reports	Emirates Annual Report	321	Comparative evidence strengthened.
10	Airline Reports	China Southern Sustainability Report	172	Existing framework confirmed.
11	Industry Reports	ICAO Environmental Report	566	Industry-wide sustainability practices incorporated.
12	Industry Reports	IATA Cabin Waste Handbook	170	Best-practice guidance reinforced existing themes.
13	Industry Reports	ESG Report 2024	124	Sustainability evidence strengthened.
14	Industry Reports	ICW Smarter Regulation Report	125	Regulatory interpretation refined.
15	Industry Reports	Aircraft from All Countries (ICAO)	42	Existing analytical framework confirmed.
16	Catering Company	Gate Gourmet Annual Report	306	Catering perspective confirmed the final analytical framework.
Total		16 Documentary Sources	2,904	Iterative coding resulted in a stable analytical framework comprising eight parent themes and 44 child codes. Later documentary sources primarily reinforced and refined the existing framework, indicating sufficient thematic coverage across the dataset.

Source: Author's own (generated from NVivo 15.4 coding summary).

3.9.3 Development of the Coding Framework and Comparative Analysis

Following the systematic coding procedure, the documentary data were analysed using a two-stage comparative case study approach consisting of within-case analysis followed by cross-case analysis (Yin, 2018). This analytical process meant that each airline was examined individually before broader patterns across all selected cases were identified. Applying the analysis in sequential stages ensured that

each airline's documentary evidence was interpreted within its own organisational context before comparisons were made across the five airline cases.

The first stage involved within-case analysis, whereby each airline was analysed independently using the coding framework developed in NVivo. Documentary evidence from Air New Zealand, Qantas, Emirates, Singapore Airlines, and China Southern Airlines was examined to identify sustainability strategies, food waste management practices, Circular Economy initiatives, resource-efficiency measures, stakeholder collaboration, regulatory constraints, and biosecurity compliance within each organisation. Analysing each airline individually allowed the researcher to understand the distinctive characteristics, priorities, and documentary emphasis of each case while maintaining consistency in the application of the coding framework across all documentary sources (Yin, 2018).

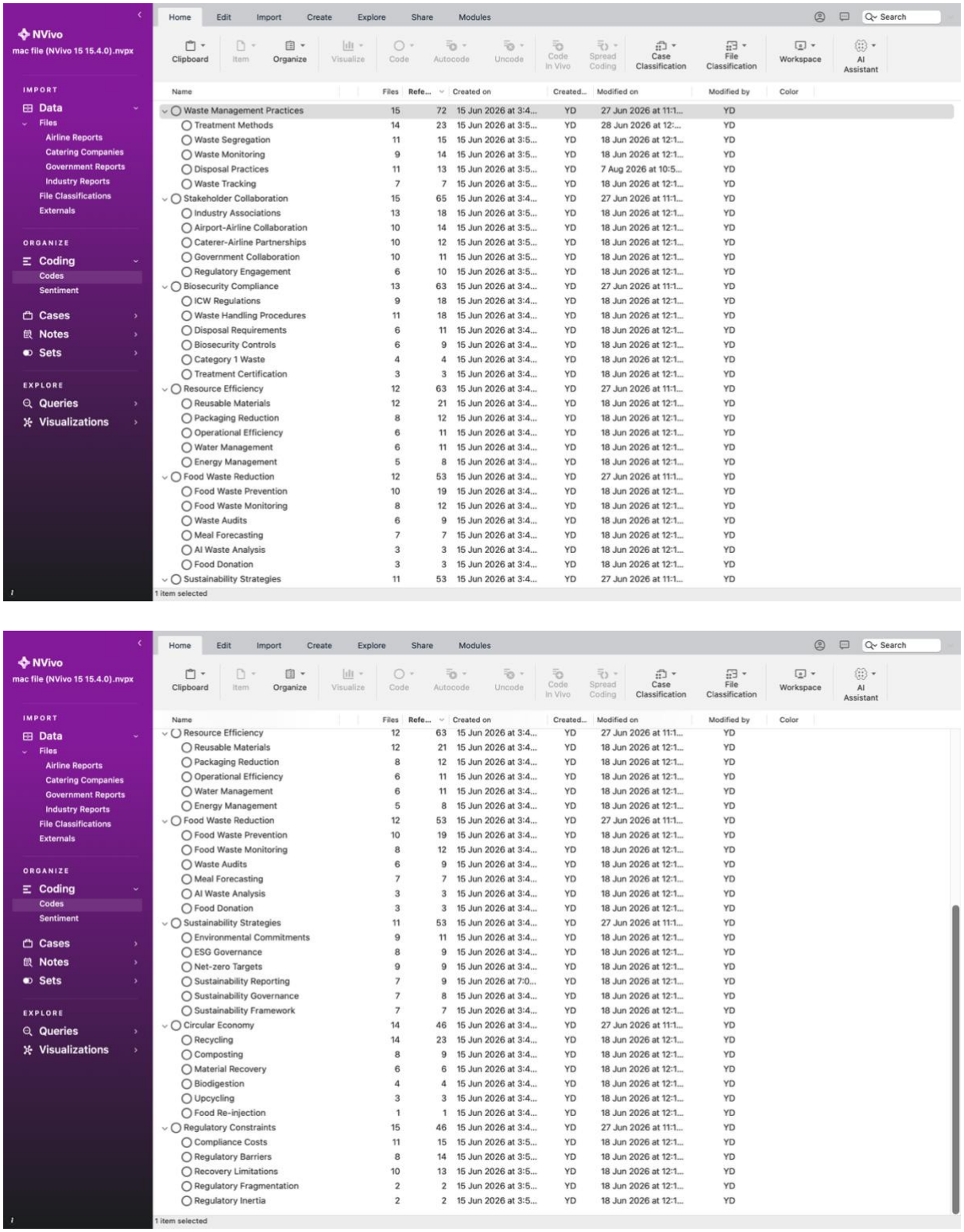
The coding framework was initially developed deductively from the literature review, the research objectives, and the Circular Economy framework before being refined iteratively through the analysis of documentary evidence. As documentary analysis progressed, the coding framework was continuously reviewed and refined, with new child codes being created, merged, or reorganised within the existing parent themes where appropriate. This iterative process ensured that the coding framework remained conceptually grounded while remaining responsive to patterns emerging from the documentary data (Braun & Clarke, 2021). The final coding framework comprised eight parent themes supported by 44 child codes and 461 coded references, which formed the analytical structure used throughout the remainder of the study. The final coding framework is presented in Table 3.5.

Table 3.5 Final Thematic Framework Developed Through Iterative NVivo Coding

Parent Theme	No. of Child Codes	Coded References (n)	Child Codes
Waste Management Practices	5	72	Treatment methods, Waste segregation, Waste monitoring, Disposal practices, Waste tracking
Stakeholder Collaboration	5	65	Industry associations, Airport–airline collaboration, Caterer–airline partnerships, Government collaboration, Regulatory engagement
Biosecurity Compliance	6	63	ICW regulations, Waste handling procedures, Disposal requirements, Biosecurity controls, Category 1 waste, Treatment certification
Resource Efficiency	5	63	Reusable materials, Packaging reduction, Operational efficiency, Water management, Energy management
Food Waste Reduction	6	53	Food waste prevention, Food waste monitoring, Waste audits, Meal forecasting, AI waste analysis, Food donation
Sustainability Strategies	6	53	Environmental commitments, ESG governance, Net-zero targets, Sustainability reporting, Sustainability governance, Sustainability frameworks
Circular Economy	6	46	Recycling, Composting, Material recovery, Biodigestion, Upcycling, Food re-injection
Regulatory Constraints	5	46	Compliance costs, Regulatory barriers, Recovery limitations, Regulatory fragmentation, Regulatory inertia
Total	44 Child Codes	461 Coded References	Final analytical framework developed through iterative hybrid coding

Source: Author's own (generated from NVivo 15.4 coding framework).

Figure 3.2: NVivo 15.4 Coding Results Showing the Final Thematic Framework



Note. Screenshots from the author's NVivo 15.4 project showing the eight parent themes, associated child codes, and coding references.

3.9.4 Cross-Case Comparative Analysis

Following the completion of the within-case analysis, a cross-case comparative analysis was undertaken to systematically compare the documentary evidence across the five selected airline cases (Air New Zealand, Emirates, Qantas, Singapore Airlines, and China Southern Airlines). Cross-case analysis enables researchers to identify similarities, differences, and recurring patterns across multiple cases while maintaining the contextual integrity of each individual case (Yin, 2018).

The comparison was undertaken using the final coding framework developed through the thematic analysis. Each airline was examined against the eight parent themes—Food Waste Reduction, Circular Economy, Sustainability Strategies, Waste Management Practices, Biosecurity Compliance, Regulatory Constraints, Stakeholder Collaboration, and Resource Efficiency—to identify common approaches as well as differences in organisational priorities and documented sustainability practices. As all five airlines operated direct international services to Auckland, the comparison was conducted within the same New Zealand biosecurity regulatory environment governing ICW. The comparison focused on patterns evident within the documentary evidence rather than evaluating or ranking the operational performance of the airlines (Yin, 2018).

The cross-case comparative analysis provided a structured basis for interpreting the documentary evidence and identifying the recurring themes that addressed the research aim and research questions. The findings arising from this comparative analysis are presented and discussed in Chapter 4.

3.10 Trustworthiness and Quality of the Research

Trustworthiness is an important criterion in qualitative research because it demonstrates that the research process has been conducted rigorously and that the findings provide a credible representation of the evidence analysed (Lincoln & Guba, 1985; Nowell et al., 2017). Rather than relying solely on statistical measures of validity and reliability, qualitative research establishes quality through principles such as credibility, dependability, confirmability, and reflexivity. These principles were considered throughout the research process to strengthen the rigour and integrity of the study.

Credibility was strengthened through the use of documentary evidence obtained from multiple sources, including airline sustainability and annual reports, MPI publications, Auckland Airport documents, International Air Transport Association (IATA) guidance, and International Civil Aviation Organisation (ICAO) reports. Examining evidence from different organisational, regulatory, and industry sources enabled airline practices and regulatory requirements to be considered from multiple perspectives and compared across the five airline cases. Dependability was supported by applying a consistent analytical framework and the same coding and analytical procedures across the documentary dataset. This

systematic approach ensured that each airline case was examined consistently and that the cross-case comparisons followed a structured analytical process (Nowell et al., 2017; Yin, 2018). The achievement of coding saturation, as described in Section 3.9.2, further supported the adequacy of the documentary analysis, as later documentary evidence reinforced the established thematic structure rather than generating substantively new parent themes (Saunders et al., 2018).

Transparency and confirmability were supported by maintaining a clear audit trail throughout the research process. Analytical decisions, coding revisions, theme development, and methodological choices were documented to provide a transparent record of how the final coding framework and interpretations were developed. This documentation enabled the analytical process to be traced from the documentary evidence through coding and theme development to the final findings, thereby strengthening the confirmability and overall rigour of the study (Lincoln & Guba, 1985; Nowell et al., 2017).

As discussed in the researcher positionality section, the researcher's professional background had the potential to influence the interpretation of the documentary evidence. To reduce this influence, interpretations were grounded in the documentary evidence, with conclusions developed through systematic coding, within-case and cross-case comparison, and evidence drawn from the selected documentary sources (Nowell et al., 2017). Table 3.6 provides an overview of the research design adopted in this study, summarising the key methodological components, including the research philosophy, paradigm, approach, case study design, sampling technique, data collection method, analytical approach, and software used.

Ethical conduct was also considered throughout the research process. As the study relied exclusively on publicly available secondary documentary sources and did not involve human participants or the collection of personal information, formal human participant ethics approval was not required. Nevertheless, care was taken to acknowledge the original sources, represent organisational information accurately, and avoid misinterpreting or overstating the documentary evidence. These considerations supported the transparency and integrity of the research process.

Table 3.6 Research Design Overview

Component	Description
Research Philosophy	Interpretivism
Research Paradigm	Qualitative Interpretivist Paradigm
Research Approach	Qualitative
Research Design	Comparative Multiple-Case Study
Data Source	Secondary Documentary Data
Cases Examined	Air New Zealand, Emirates, Qantas, Singapore Airlines, China Southern Airlines
Geographical Context	Auckland, New Zealand
Sampling Technique	Purposive Sampling
Data Collection Method	Documentary Data Collection
Data Analysis Technique	Hybrid Thematic Analysis (Deductive and Inductive Coding)
Software Used	NVivo 15.4

3.11 Chapter Summary

This chapter outlined the methodological framework adopted for the study and justified the research design used to investigate sustainable in-flight food waste management among airlines operating direct international services to Auckland. The chapter explained the interpretivist research philosophy and paradigm, qualitative comparative multiple-case study design, purposive sampling strategy, documentary data collection, and the analytical procedures used to examine the documentary evidence. It also described the measures adopted to enhance the trustworthiness and quality of the research. Collectively, these methodological decisions provide a transparent and rigorous foundation for Chapter 4, which presents the findings and discussion arising from the thematic analysis of the selected airline cases.

Chapter 4: Findings and Discussion

4.1 Introduction

This chapter presents and discusses the findings of the thematic analysis of documentary data relating to the in-flight food waste management practices of five major airlines operating direct flights to Auckland, New Zealand. The analysis identified eight key themes: Food Waste Reduction, Circular Economy, Sustainability Strategies, Waste Management Practices, Biosecurity Compliance, Regulatory Constraints, Stakeholder Collaboration, and Resource Efficiency.

The chapter begins by presenting the findings for each theme, drawing on evidence from airline sustainability reports, regulatory publications, and industry documents. The findings are then discussed in relation to the literature reviewed in Chapter 2 and interpreted within the context of the Circular Economy framework. Finally, a cross-case analysis compares the five airline cases to identify common practices, key differences, and shared challenges associated with balancing sustainable in-flight food waste management with New Zealand's stringent biosecurity requirements.

4.2 Overview of Findings

The thematic analysis identified eight parent themes across the documentary dataset: Food Waste Reduction, Circular Economy, Sustainability Strategies, Waste Management Practices, Biosecurity Compliance, Regulatory Constraints, Stakeholder Collaboration, and Resource Efficiency. These themes were developed through the hybrid coding process described in Chapter 3 and provide the analytical structure for the findings and discussion presented in this chapter.

4.3 Food Waste Reduction

Food waste reduction emerged as an important theme across the five airline cases, reflecting a shared organisational commitment to preventing unnecessary food waste throughout airline catering operations. Documentary analysis identified a range of preventative practices, including meal forecasting, demand-based catering, operational planning, waste monitoring, waste audits, artificial intelligence (AI)-supported analysis, and food donation initiatives. Although the level of implementation differed across organisations, the comparison indicated that waste prevention was consistently prioritised over managing waste after it had already been generated. These findings suggest that food waste reduction has become an important component of airline sustainability strategies, supporting both environmental objectives and operational efficiency.

A cross-case comparison revealed that all five airline cases prioritised preventing food waste before it was generated; however, the strategies adopted differed according to organisational priorities and operational responsibilities. Singapore Airlines encouraged passengers to “pre-order or skip meals” before departure to reduce unnecessary catering and better align meal production with passenger

demand (Singapore Airlines, 2025, p. 46). Similarly, China Southern Airlines implemented its "Green Flight-On-demand Meal" programme, reporting a 4.83% year-on-year increase in passenger participation, demonstrating a demand-based approach to reducing surplus meals (China Southern Airlines, 2025). Similarly, gategroup reported that "advanced forecasting, precise batch planning, and close customer collaboration" (gategroup, 2024, p. 176) contributed to a 15% reduction in food waste over two years. Industry guidance reinforced these operational practices by recommending that airlines allow passengers to "pre-select meal choices before departure" (IATA, 2024a, p. 35) to improve catering accuracy and minimise unnecessary food preparation. Collectively, these findings indicate that while airlines primarily focused on passenger-centred initiatives to improve demand forecasting, catering providers placed greater emphasis on production planning and operational efficiency to achieve similar waste reduction outcomes.

While waste prevention was the primary focus across the airline cases, analysis of the selected documents also identified several supporting operational practices aimed at continuously improving food waste management. Waste monitoring and waste audits were commonly used to evaluate operational performance and identify opportunities for further improvement. Air New Zealand, Qantas, and Singapore Airlines reported monitoring waste streams and reviewing operational practices as part of their broader sustainability programmes, while industry guidance recommended establishing baseline waste measurements and undertaking periodic cabin waste composition analyses to support evidence-based decision-making (IATA, 2019). Technological innovation was also evident across the analysed documents. Emirates reported using "AI-driven automation and smart camera technology" (Emirates Group, 2025, p. 77) to improve production efficiency, strengthen food safety, and monitor waste generation, while the gategroup ESG Report described AI-supported provisioning systems and food waste analysis that enabled more accurate menu planning and reduced over-provisioning. In contrast, food donation was identified less frequently across the analysed documents. Where implemented, gategroup reported donating surplus food to local non-profit organisations; however, such initiatives remain limited within international aviation because New Zealand's biosecurity regulations prohibit the redistribution of food from international flights (MPI, 2021; MPI, 2025).

These findings are consistent with previous research identifying over-catering, passenger demand uncertainty, food safety requirements, and service expectations as key contributors to airline food waste (Halizahari et al., 2021; Li, 2024; You et al., 2020). Analysis of the selected documents indicates that the participating organisations increasingly address these challenges through preventative operational strategies integrated into catering and production processes. Rather than concentrating primarily on waste disposal after meals have been prepared, the organisations emphasised demand-based catering, production planning, waste monitoring, and technological innovation to reduce unnecessary resource consumption before waste is generated. This shift reflects the Circular Economy principle of waste prevention, which prioritises avoiding waste at its source before considering recovery, recycling, or

disposal (Geissdoerfer et al., 2020; Kirchherr et al., 2017). The findings therefore suggest that food waste reduction within the airline industry is becoming a proactive operational strategy embedded within day-to-day catering practices rather than a reactive waste management activity.

Despite the range of food waste reduction initiatives identified across the five airline cases, the analysis indicates that completely eliminating food waste remains unrealistic within commercial aviation. Airlines may carry surplus or contingency meals to accommodate fluctuations in passenger demand, operational disruptions, and service quality requirements (Jainudeen Nawas, 2025; Li, 2024). Consequently, some degree of surplus food may remain despite continued improvements in forecasting, production planning, and waste monitoring. Nevertheless, the findings demonstrate that food waste reduction is increasingly embedded within airline catering operations through preventative planning, technological innovation, and collaboration between airlines and catering providers. These practices not only contribute to environmental sustainability but also improve operational efficiency and resource utilisation, highlighting food waste prevention as a key component of sustainable airline catering.

4.4 Circular Economy

Circular Economy-related practices were identified across the five airline cases, although their implementation varied according to organisational priorities and operational requirements. The documentary evidence demonstrated that airlines increasingly view waste as a resource that can be recovered, reused, or repurposed rather than simply disposed of. Across the five cases, the most frequently identified Circular Economy practices included recycling, material recovery, composting, biodigestion, upcycling, and food re-injection. Among these, recycling emerged as the dominant practice, while the remaining initiatives were implemented where operationally feasible and legally permitted. Collectively, these findings demonstrate a growing organisational commitment to reducing waste and improving resource efficiency through Circular Economy approaches.

The cross-case analysis highlighted differences in how airlines approached recycling. Emirates reported that “damaged or unusable meal service items – such as plastic trays, bowls, snack containers and casserole dishes – are recycled into new ready-to-use meal service products” (Emirates Group, 2025, p. 74). China Southern Airlines established “recycling stations in the catering facility for airline meal packaging waste such as plastic bottles, cartons, and metal cans” and engaged third-party recycling companies for collection and processing (China Southern Airlines, 2025, p. 106). Singapore Airlines stated that it “tracks the amount of waste generated and recycled from its flight operations”, supported by monthly waste audits conducted by SATS Ltd (Singapore Airlines, 2025, p. 46). Qantas reported collecting “4,041 tonnes of material from priority waste streams including organics, container deposit scheme, comingled recycling, cardboard, timber, plastic and metals” across its domestic operations (Qantas Group, 2025, p. 74). Within the catering sector, gategroup also reported implementing closed-loop recycling processes in collaboration with major airlines, in which materials are recovered and

returned for further use (gategroup, 2025, p. 178). These approaches demonstrate different organisational priorities: Emirates focused on returning meal-service items into use, China Southern Airlines on source segregation, Singapore Airlines on monitoring recycling performance, Qantas on recovering material across multiple waste streams, and gategroup on closed-loop material recovery.

Beyond recycling, broader circular resource and material strategies were evident across multiple organisations. Air New Zealand reported incorporating a "Circular Economy clause in our supply agreements" to encourage suppliers to reduce waste and identify opportunities for reuse or repurposing (Air New Zealand, 2025). China Southern Airlines reported achieving "100% degradable alternatives for on-board plastic products" through updated standards and product lists (China Southern Airlines, 2025, p. 104). Emirates also established waste recovery targets and reported recycling 4,590 tonnes of pallets, paper, glass bottles, cardboard, and plastic (Emirates Group, 2025, p. 77). These initiatives demonstrate that Circular Economy practices extend beyond conventional recycling to include procurement decisions, material substitution, and recovery strategies intended to retain resource value and reduce disposal.

The analysis also identified composting and bio-digestion as Circular Economy practices, although these appeared less frequently than recycling in the analysed documents. Bio-digestion involves the biological treatment of organic waste to produce recoverable outputs such as biogas or liquid by-products. Emirates reported that its "LFC-50 biodigester processes up to 150 kg of food waste daily", converting it into greywater while reducing landfill waste and carbon emissions (Emirates Group, 2025, p. 77). Similarly, gategroup reported that its Paris and Zurich operations worked with external partners to collect organic waste, ferment it, and convert it into biogas (gategroup, 2025, p. 175). gategroup also reported "composting kitchen food and liquid waste where possible" as part of its waste-management hierarchy (gategroup, 2025, p. 173). Auckland Airport reported that 295 tonnes of food waste were sent to compost during FY25 and described an MPI-approved process at the Strata Lounge that redirects food waste from kitchen and service-preparation areas into a compost stream (Auckland Airport, 2025a, p. 53). Food re-injection, however, was identified only within industry guidance rather than as a reported practice among the five airline cases. Overall, composting, biodigestion, and food re-injection appeared less frequently than recycling within the documentary dataset.

The findings demonstrate that Circular Economy principles are increasingly embedded within airline sustainability strategies through initiatives focused on recycling, material recovery, waste prevention, and resource recovery. These findings align with Kirchherr et al. (2017), who described the Circular Economy as a system that seeks to maintain the value of products, materials, and resources for as long as possible while minimising waste generation. Similarly, Geissdoerfer et al. (2020) argued that Circular Economy approaches require organisations to move beyond waste disposal towards resource regeneration and value retention. However, the cross-case analysis also revealed a clear tension between

Circular Economy principles and operational practice within the New Zealand context. Although airlines reported initiatives involving recycling, composting, biodigestion, and material recovery, opportunities to apply some of these practices to ICW arriving in New Zealand are constrained by biosecurity treatment and disposal requirements (MPI, 2021; MPI, 2025). Qantas similarly noted that quarantine waste is treated as a specialised waste stream subject to biosecurity requirements and is excluded from its recoverable solid-waste measure (Qantas Group, 2025, p. 74). Consequently, successful implementation of Circular Economy principles depends not only on organisational commitment but also on the regulatory environment in which airlines operate. These findings suggest that greater collaboration between airlines, airports, waste-management providers, and regulatory agencies will be required to develop resource-recovery solutions that maintain New Zealand's biosecurity standards while supporting a more circular aviation catering system.

4.5 Sustainability Strategies

Sustainability strategies emerged as a prominent theme across the five airline cases, indicating that environmental sustainability is increasingly integrated into long-term organisational planning rather than treated as a standalone environmental initiative. The analysed documents showed that sustainability was embedded through governance frameworks, environmental targets, carbon reduction strategies, and operational commitments. For example, Qantas identified sustainability as one of its strategic priorities (Qantas Group, 2025), while Singapore Airlines stated that sustainability "will be anchored across all levels of the organisation" (Singapore Airlines, 2025, p. 10). China Southern Airlines developed its Dual Carbon approach and published its 2025 Green Development White Paper to support its low-carbon transition (China Southern Airlines, 2025). These examples indicate that sustainability is increasingly incorporated into organisational strategy and decision-making rather than being treated solely as an environmental reporting activity.

A cross-case comparison further demonstrated differences in how the airlines integrated sustainability into their governance structures. Singapore Airlines described sustainability as "an integral part of SIA's business operations and strategy" and established Board and management oversight supported by policies, risk management, due diligence, and climate target setting (Singapore Airlines, 2025, p. 10). Qantas incorporated ESG considerations into its broader strategic and governance framework (Qantas Group, 2025), while Emirates incorporated ESG risk management into procurement, including identifying and mitigating ESG risks and integrating these considerations into strategic procurement processes (Emirates Group, 2025, pp. 99–100). China Southern Airlines used climate-related targets and monitoring mechanisms to track progress, while gategroup aligned its governance processes with recognised sustainability reporting standards, including ESRS, CSRD, and TCFD requirements (gategroup, 2025). The differences therefore lie in how sustainability is governed: Singapore Airlines emphasised organisation-wide Board and management accountability, Emirates incorporated ESG into

procurement risk management, China Southern Airlines emphasised target monitoring, while Qantas and gategroup integrated sustainability through broader governance and reporting frameworks.

Environmental commitments were also evident through long-term carbon reduction and operational targets. China Southern Airlines reported commitments to “Carbon Peaking and Carbon Neutrality goals” and established progressive carbon reduction targets extending to 2060 (China Southern Airlines, 2025). Singapore Airlines aligned its net-zero target with the aviation industry's goal of achieving “net zero carbon emissions from operations by 2050” (Singapore Airlines, 2025, p. 28). Emirates structured its environmental strategy around three pillars: “reducing emissions, consuming responsibly, and preserving wildlife and habitats” (Emirates Group, 2025, p. 62). Within the wider catering value chain, gategroup identified ambitions to reach net-zero carbon and “avoid operational waste and prioritise recycling” (gategroup, 2025). At the industry level, ICAO's long-term global aspirational goal of net-zero emissions by 2050 reinforces the wider direction of sustainability strategy within international aviation (ICAO, 2025).

Despite these shared commitments, the comparison also revealed a gap between strategic sustainability ambitions and what can be implemented operationally. The airline and catering documents demonstrated commitments to waste reduction, recycling, resource efficiency, and Circular Economy practices; however, opportunities for some forms of resource recovery are constrained when ICW enters New Zealand's biosecurity system. For example, gategroup's commitment to “avoid operational waste and prioritise recycling” (gategroup, 2025) illustrates the sustainability objective at the organisational level, while New Zealand's biosecurity requirements restrict how ICW can subsequently be recovered, reused, or treated. Under MPI's Import Health Standard and Aircraft Risk Management Standard, this waste is subject to controlled treatment and disposal requirements (MPI, 2021; MPI, 2025). The findings therefore demonstrate that strong organisational sustainability commitments do not automatically translate into equivalent operational outcomes when waste-management practices are constrained by regulatory requirements.

These findings are consistent with Sharmina et al. (2021), who argued that sustainability has become increasingly integrated into organisational decision-making in response to environmental concerns, stakeholder expectations, and global climate commitments. From a Circular Economy perspective, the evidence suggests that these organisational sustainability frameworks can support efforts to improve resource efficiency and reduce waste, aligning with Circular Economy principles of waste minimisation and resource retention (Kirchherr et al., 2017). However, the cross-case comparison also demonstrates that greater circularity depends on the interaction between organisational strategy and the wider regulatory environment. Consequently, collaboration among airlines, airports, catering providers, waste-management organisations, and government agencies remains important for translating sustainability commitments into practical waste-management outcomes (Salesa et al., 2023).

Overall, sustainability strategies across the five airline cases extended beyond environmental reporting and were increasingly embedded within corporate governance, long-term planning, risk management, and operational objectives. The variation between cases was primarily evident in how these commitments were implemented, ranging from carbon reduction strategies and ESG governance to waste reduction and resource efficiency. However, the New Zealand context demonstrates that organisational ambition must operate alongside strict biosecurity requirements. Achieving more sustainable airline catering therefore requires an integrated approach in which environmental objectives, operational practices, and regulatory compliance are considered together.

4.6 Waste Management Practices

Waste management practices emerged as a fundamental theme across the five airline cases, highlighting the importance of integrated waste management systems in supporting environmental sustainability and regulatory compliance. The analysis of the selected documents identified four interconnected operational practices: waste segregation, waste tracking, waste monitoring, and treatment and disposal methods. Although the implementation of these practices varied across organisations, the documentary evidence demonstrated structured approaches to waste management across the airline and catering operations examined. Collectively, the findings indicate that effective waste management extends beyond the safe disposal of waste by incorporating monitoring, operational control, and regulatory compliance to improve resource efficiency and minimise environmental impacts.

A cross-case comparison showed differences in how organisations managed waste according to their operational responsibilities. China Southern Airlines established recycling stations within its catering facilities to separate airline meal packaging waste, including plastic bottles, cartons, and metal cans, before these materials were collected by third-party recycling companies (China Southern Airlines, 2025, p. 106). This demonstrates source segregation, whereby different waste materials are separated to facilitate subsequent recycling. Singapore Airlines reported implementing waste-management practices across its operations to reduce waste generation and monitored waste generated and recycled from flight operations (Singapore Airlines, 2025, p. 46). Qantas focused on improving waste-management processes with contracted suppliers (Qantas Group, 2025), while gategroup worked with external partners to collect organic waste from its Paris and Zurich operations for fermentation and conversion into biogas (gategroup, 2025, p. 175). These findings demonstrate different operational approaches, ranging from segregation and monitoring to supplier collaboration and organic waste recovery.

In addition to waste segregation, waste tracking and monitoring were identified as important components of waste management. Air New Zealand reported sending 1,041 tonnes of waste to landfill while diverting 47% of its total waste from landfill (Air New Zealand, 2025). The 47% therefore refers to the proportion of total waste diverted rather than 47% of the 1,041 tonnes sent to landfill. The ICAO

Environmental Report described how Amsterdam Airport Schiphol tracks waste by weight, type, and source throughout airport operations (ICAO, 2025). Within the catering sector, gategroup reported monitoring composting and cooking-oil recycling programmes across its production facilities (gategroup, 2025), while China Southern Airlines reported monitoring wastewater, waste gas, and solid-waste emissions as part of its environmental management programme (China Southern Airlines, 2025). The China Southern evidence establishes that these waste streams were monitored; it does not establish how the resulting information was subsequently used. Collectively, the findings show that the organisations differed in what they measured, ranging from landfill diversion and waste composition to recycling programmes and environmental emissions.

The analysis also identified treatment and disposal practices as essential components of waste management, particularly for ICW. Treatment and disposal options were strongly influenced by applicable biosecurity and environmental requirements. The ICW Smarter Regulation Report identified treatment methods including “steam sterilisation (autoclaving), incineration, deep landfill and engineered landfill” for managing ICW (Food Control Consultants Ltd., 2024). Similarly, MPI's Import Health Standard requires regulated aircraft waste to be transported to approved facilities for treatment and disposal (MPI, 2025). Auckland Airport's Airfield Waste Management Plan further outlines procedures for the collection, handling, and disposal of operational waste to minimise environmental and biosecurity risks (Auckland Airport, 2024a). The findings therefore demonstrate that treatment and disposal represent a distinct component of waste management alongside the preventative and recovery practices identified across the airline and catering documents.

These findings demonstrate that waste management within international aviation extends beyond collection and disposal to encompass waste segregation, tracking, monitoring, treatment, and regulatory compliance. The findings are consistent with previous literature highlighting the growing importance of waste reduction and resource efficiency within aviation sustainability strategies (Sharmina et al., 2021). From a Circular Economy perspective, effective waste management should prioritise waste prevention, resource optimisation, and value retention rather than relying solely on end-of-life disposal (Alabi et al., 2025; Kirchherr et al., 2017). The findings in this section therefore demonstrate the different operational mechanisms used to manage waste, while the implications of New Zealand's biosecurity requirements for these practices are examined in the subsequent regulatory themes.

Overall, the findings demonstrate that effective waste management within the five airline cases relies on a combination of waste segregation, tracking, monitoring, treatment, and disposal practices. The comparison identified differences in organisational emphasis, including source segregation, waste measurement, supplier collaboration, organic waste recovery, and regulated treatment. These practices demonstrate that waste management involves multiple stages and stakeholders across airline and catering operations rather than being limited to final disposal.

4.7 Biosecurity Compliance

Biosecurity compliance emerged as an important theme within the analysis, reflecting the significant influence of New Zealand's regulatory framework on airline waste management practices. Documentary evidence identified Biosecurity Controls, Category 1 Waste, Waste Handling Procedures, Disposal Requirements, Treatment Certification, and ICW Regulations as the principal sub-themes underpinning compliance with biosecurity requirements. Collectively, these findings demonstrate that biosecurity compliance is a fundamental operational requirement that governs how airlines manage, transport, treat, and dispose of catering waste generated from international flights operating into New Zealand.

Biosecurity Controls emerged as a key sub-theme, with documentary evidence demonstrating strict measures to prevent contamination and manage biosecurity risks associated with ICW. The Biosecurity Rules of New Zealand require that food must not be transferred from airside to landside without prior approval from MPI, while cabin waste must be removed from aircraft as soon as practicable and transported to an approved Transitional Waste Facility for sorting under an MPI-approved system (Auckland Airport, 2019; MPI, 2021). The Aircraft from All Countries Craft Risk Management Standard also requires biosecurity contamination and regulated risk goods remaining onboard aircraft to be securely contained and managed in accordance with prescribed procedures (MPI, 2021). China Southern Airlines reported certification under ISO 22000 and HACCP, with controls applied from raw-material procurement through food processing and meal delivery to manage food hygiene and safety risks (China Southern Airlines, 2025, p. 66). Collectively, these findings indicate that biosecurity and food-safety controls operate across different stages of airline catering and waste-management processes.

Beyond these regulatory controls, the analysed documents demonstrated that biosecurity compliance directly shapes waste-handling procedures. Requirements for secure onboard containment, timely removal of cabin waste, and controlled transportation to approved facilities specify how ICW must be managed after an international flight arrives in New Zealand (Auckland Airport, 2019; MPI, 2021). These requirements therefore translate regulatory obligations into specific handling procedures undertaken during aircraft servicing and waste removal.

The analysed documents further demonstrate that biosecurity compliance extends to the treatment and disposal of ICW through approved processes and facilities. The International Catering Waste Smarter Regulation Report identifies permitted disposal methods including “incineration”, “pressure sterilisation/autoclaving”, “deep landfill burial”, and disposal in an authorised landfill (Food Control Consultants Ltd., 2024, p. 13). The 2024 update similarly confirms that ICW regulations allow treatment and disposal methods including incineration, steam sterilisation, deep landfill burial, and authorised landfill disposal. MPI requirements also require regulated aircraft waste to be managed through approved treatment and disposal processes (MPI, 2025). Auckland Airport's Airfield Waste Management Plan outlines procedures for the collection, transportation, and disposal of operational

waste within the New Zealand airport environment (Auckland Airport, 2024a). These findings demonstrate that ICW treatment and disposal are subject to controlled processes intended to manage biosecurity risk.

These findings further highlight biosecurity compliance as a defining feature of airline waste management within the New Zealand context, influencing practices from waste handling through to final treatment and disposal. This is consistent with previous literature highlighting the role of biosecurity controls in reducing risks associated with ICW and the international movement of potentially risk-bearing biological materials (Pennington et al., 2025; Riasari et al., 2021). The evidence also shows why some waste-management options identified elsewhere in the analysis cannot automatically be applied to ICW: the permitted handling and treatment pathway is determined by applicable biosecurity requirements. This regulatory influence is examined further in the following section on Regulatory Constraints.

Overall, the findings demonstrate that biosecurity compliance shapes how ICW is contained, removed, transported, treated, and disposed of within New Zealand. Although organisations may use different internal procedures to support compliance, they operate within a common regulatory framework governing biosecurity-risk material. Biosecurity compliance therefore forms an operational component of international airline waste management rather than functioning solely as an external regulatory requirement.

4.8 Regulatory Constraints

Regulatory constraints emerged as a significant cross-cutting theme within the analysis, demonstrating that regulatory requirements strongly influence the implementation of sustainable food waste management practices within international aviation. Documentary evidence from airline sustainability reports, government publications, industry reports, and catering company documents identified biosecurity legislation, mandatory disposal requirements, compliance obligations, and operational regulations as factors shaping food waste management practices. Across the five airline cases, the evidence showed that while airlines demonstrated commitments towards sustainability and Circular Economy initiatives, regulatory requirements limited opportunities for food redistribution, recycling, composting, and other forms of resource recovery associated with ICW. These findings indicate that regulatory compliance remains an important consideration in how airlines manage food waste.

The documentary evidence also identified financial and operational pressures associated with sustainability and regulatory compliance. Air New Zealand reported supply-chain and resource challenges, while Emirates acknowledged that sustainable procurement can involve higher short-term costs and Singapore Airlines identified cost pressures associated with sustainability initiatives (Air New Zealand, 2025; Emirates Group, 2025; Singapore Airlines, 2025). Industry evidence more directly

demonstrated the financial implications of ICW management. The ICW Smarter Regulation Report reported that handling, management, and disposal costs vary from "US$125/tonne at Schiphol Airport (AMS) to US$500/tonne at Hartsfield–Jackson Atlanta International Airport (ATL)" (IATA, 2024a, p. 13). New Zealand requirements similarly place responsibility for relevant treatment and disposal costs on organisations handling biosecurity-risk waste (Auckland Airport, 2019; MPI, 2025). Collectively, the evidence indicates that regulatory compliance can create additional financial and operational obligations associated with ICW management.

Regulatory complexity also limited opportunities for resource recovery. gategroup observed that despite challenges to existing ICW regulations by airlines, caterers, and airport operators, "significant regulatory shifts have yet to be realized" (gategroup, 2025, p. 172). Qantas similarly identified "fragmented regulations" and inconsistent recycling standards across jurisdictions as challenges to expanding waste-recovery initiatives (Qantas Group, 2025, p. 74). The ICW Smarter Regulation Report stated that growing environmental policies concerning food waste and landfill mean that "current ICW regulations are diametrically opposed to future environmental policies" (IATA, 2024a, p. 30). It also reported that where catering facilities treat domestic and international waste together as ICW, "none of this waste is currently eligible for recycling" (IATA, 2024a, p. 33). Together, these findings demonstrate that differences in regulatory requirements and waste classification can restrict the implementation of recycling and resource-recovery practices.

The findings indicate that regulatory systems play a decisive role in determining the extent to which sustainable food waste management practices can be implemented within international aviation. Although biosecurity legislation serves an important role in protecting animal and plant health, the evidence demonstrates that regulatory requirements can also restrict opportunities for recycling, reuse, and resource recovery. These findings are consistent with previous literature showing that regulatory and biosecurity requirements can constrain sustainable waste-management options within international aviation (Pennington et al., 2025; Salesa et al., 2023). The evidence therefore suggests that airline sustainability initiatives are influenced not only by organisational commitment but also by the regulatory conditions governing ICW.

From a Circular Economy perspective, regulatory requirements create barriers to closing resource loops within ICW management. While Circular Economy principles advocate waste prevention, reuse, recycling, and material recovery (Kirchherr et al., 2017), mandatory treatment and disposal requirements can interrupt these resource flows by limiting the recovery of materials that might otherwise be reused or recycled. Overall, the findings suggest that greater collaboration between regulators, airlines, airports, catering providers, and waste-management organisations may support regulatory approaches that maintain New Zealand's biosecurity protection while creating greater opportunities for safe resource recovery.

4.9 Stakeholder Collaboration

Stakeholder Collaboration highlights the role of coordinated partnerships in supporting sustainable food waste management within the aviation sector. The analysis of the selected documents identified caterer–airline partnerships, airport–airline collaboration, government collaboration, industry engagement, and regulatory collaboration as the principal forms of stakeholder interaction supporting operational efficiency, regulatory compliance, and environmental sustainability. Although the nature of these partnerships varied across organisations, the findings demonstrated that sustainable food waste management depends on coordinated action among multiple stakeholders across the aviation supply chain.

The documentary evidence showed that stakeholder collaboration was recognised across different organisations as an important mechanism for supporting sustainability. Singapore Airlines reported working with government agencies and industry partners on sustainability initiatives, including collaboration with Changi Airport Group and Singapore government agencies to assess and support the development of sustainable aviation fuel (Singapore Airlines, 2025, p. 35). The airline concluded that successful implementation required active collaboration across the aviation value chain. China Southern Airlines similarly established formal stakeholder communication channels involving government, customers, employees, suppliers, financial institutions, communities, and industry peers to support sustainable development (China Southern Airlines, 2025, pp. 17–18). Within the catering sector, gategroup reported working with customers, suppliers, industry organisations, and airline partners on aviation-waste initiatives, including recycling trials and regulatory engagement (gategroup, 2025, p. 172). These findings demonstrate that collaboration differs according to organisational role, ranging from government and airport partnerships to supply-chain and industry cooperation.

Beyond organisational partnerships, stakeholder collaboration was also evident through coordinated operational initiatives. Auckland Airport reported working with airlines, government agencies, service providers, and other stakeholders on waste-management and sustainability activities (Auckland Airport, 2025b). Industry guidance similarly emphasises cooperation and the development of consistent approaches to waste management across the aviation sector (IATA, 2019). Rather than relying on individual organisations, these forms of collaboration support knowledge sharing, coordinated decision-making, and the implementation of operational practices across multiple parts of the aviation system.

The analysed documents further demonstrate that stakeholder collaboration extends to government and regulatory engagement. New Zealand's biosecurity requirements require airlines, airports, and waste service providers to operate within MPI-approved arrangements for managing biosecurity-risk waste (MPI, 2021; MPI, 2025). The ICW Smarter Regulation Report also emphasises active cooperation among airlines, catering companies, airports, government policymakers, and enforcement authorities when developing risk-management approaches for ICW (IATA, 2024a, p. 31). The report further argues

that greater reuse and recycling of international-flight waste will require constructive dialogue between governments and the airline sector. These findings indicate that regulatory collaboration is particularly important where sustainability initiatives must operate alongside biosecurity requirements.

These findings demonstrate that stakeholder collaboration can facilitate coordinated decision-making, knowledge sharing, and regulatory compliance across the airline catering supply chain. This is consistent with previous literature highlighting the importance of coordination among airlines, airports, catering providers, and waste-management stakeholders in improving sustainable waste-management practices within aviation (Salesa et al., 2023). From a Circular Economy perspective, collaboration can also support waste reduction, resource efficiency, and material recovery by bringing together organisations responsible for different stages of the waste-management process (Kirchherr et al., 2017). Within the New Zealand context, cooperation between operational stakeholders and regulators is particularly important because sustainability initiatives must remain compatible with biosecurity requirements.

Overall, the findings demonstrate that stakeholder collaboration occurs through operational partnerships, government engagement, supply-chain cooperation, and regulatory coordination. The comparison indicates that airlines cannot manage sustainable catering waste solely through internal initiatives because waste generation, collection, treatment, regulation, and recovery involve multiple organisations. Effective coordination among airlines, airports, catering providers, waste-management organisations, industry bodies, and regulators therefore supports more integrated approaches to sustainable food waste management.

4.10 Resource Efficiency

Another recurring theme in the data was resource efficiency. The thematic analysis identified Packaging Reduction, Reusable Materials, Water Management, Energy Management, and Operational Efficiency as the principal sub-themes. The prevalence of these discussions across the dataset suggests that the airlines are addressing resource consumption through operational improvements and resource optimisation rather than relying solely on downstream waste-management practices.

The documentary evidence identified a range of initiatives aimed at reducing packaging waste, minimising single-use plastics, and improving the use of reusable or recyclable materials across airline and catering operations. However, the approaches adopted differed across organisations. China Southern Airlines reported updating 150 items across five categories, including tableware, packaging bags, stirrers, cups, and packaging films, and achieving “100% degradable alternatives for on-board plastic products” (China Southern Airlines, 2025, p. 104). Emirates reported that dnata Catering UK saved 25 tonnes of plastic in six months after replacing plastic cutlery with wooden alternatives (Emirates Group, 2025, p. 74). Emirates also reported that replacing plastic sandwich packaging with

food-safe cardboard reduced plastic waste by 45,000 kg annually (Emirates Group, 2025, p. 77). gategroup demonstrated material optimisation through Evertaste Germany, where its carton packaging portfolio was reduced from 12 formats to two, using approximately 18% less material per box and saving more than 123,000 boxes annually (gategroup, 2025, p. 176). Collectively, these findings demonstrate different approaches to material efficiency through material substitution, packaging redesign, and reduced reliance on single-use materials.

Beyond material optimisation, the airline cases demonstrated resource efficiency through water management, energy management, and operational improvements. China Southern Airlines reported that the introduction of aircraft dry-cleaning technology across its maintenance units saved 602,000 tonnes of water by the end of 2025 (China Southern Airlines, 2025, p. 104). Singapore Airlines reported that its upcoming Airbus A350F freighters will consume around 40% less fuel than its existing Boeing 747-400Fs on similar operations (Singapore Airlines, 2025, p. 1). The airline also established a target to reduce energy consumption in its Singapore-owned buildings by 10% from FY2019/20 levels by FY2029/30 (Singapore Airlines, 2025, p. 18). China Southern Airlines further reported that its Paperless Initiative had "significantly enhanced overall ground and cabin service efficiency" by digitising operational documents and service processes (China Southern Airlines, 2025, p. 108). Together, these findings demonstrate that resource efficiency extends beyond material use to include water conservation, energy efficiency, fuel efficiency, and digital operational processes.

The findings also indicate links between resource efficiency and Circular Economy practices through the continued use and recovery of materials. Qantas reported collecting 4,041 tonnes of material from priority waste streams, including organics, recycling, cardboard, timber, plastics, and metals across its domestic operations (Qantas Group, 2025, p. 74). Singapore Airlines reported tracking the amount of waste generated and recycled from its flight operations, supported by monthly waste audits undertaken by SATS Ltd (Singapore Airlines, 2025, p. 47). gategroup similarly described developing food packaging and serviceware products intended to support circularity, with newly introduced deSter products since 2020 designed to be reusable, recyclable, or compostable (gategroup, 2025, p. 177). These examples demonstrate how resource efficiency can support material retention and recovery across airline and catering operations.

These findings demonstrate that resource efficiency extends beyond waste reduction to encompass the efficient use of materials, energy, water, and operational resources. The analysis indicates that organisations adopted measures including packaging redesign, material substitution, energy-efficient technology, water conservation, and operational digitisation. This is consistent with Circular Economy literature emphasising waste reduction, resource retention, and the continued use of materials within more circular systems (Kirchherr et al., 2017). Geissdoerfer et al. (2020) similarly argued that

sustainable systems require organisations to optimise resource use throughout the product lifecycle rather than relying solely on waste treatment and disposal.

Overall, the findings demonstrate that resource efficiency provides a practical approach to reducing environmental impacts while supporting operational performance. Although the initiatives varied between organisations, the analysed documents showed improvements in packaging, material use, water conservation, energy management, and operational processes. Rather than focusing solely on downstream waste management, the cases demonstrate the importance of optimising resource use at source as part of more sustainable airline operations.

4.11 Cross-Case Comparison of Themes Across the Five Airline Cases

The cross-case analysis presented in the preceding thematic sections identified similarities and differences across Air New Zealand, China Southern Airlines, Emirates, Qantas, and Singapore Airlines. This section provides an overall comparison of the relative prominence of the eight themes within each airline's documentary evidence. Table 4.1 summarises this comparison using the number of coded references recorded in NVivo. A coded reference represents a distinct extract of documentary evidence assigned to a theme during the coding process. Therefore, the values represent the number of separately coded extracts relating to each theme rather than the number of times a particular word or phrase appeared. Where a longer section of a document contained several distinct relevant extracts, these could be coded separately. The values therefore indicate thematic prominence within the analysed documents and do not measure organisational performance.

The cross-case comparison revealed both commonalities and differences in the prominence of the eight themes. Sustainability Strategies received relatively consistent emphasis across the five airlines, with particularly high numbers of coded references for China Southern Airlines and Singapore Airlines. Resource Efficiency was also prominent for China Southern Airlines and Emirates, whereas Food Waste Reduction was most prominent within the Emirates documentary evidence. Waste Management Practices received its highest emphasis within China Southern Airlines, while Regulatory Constraints showed relatively little variation across the five cases.

Greater differences were evident for Stakeholder Collaboration and Biosecurity Compliance. China Southern Airlines contained the highest number of references to Biosecurity Compliance, while no references to this theme were identified within the Air New Zealand or Emirates airline documents included in the dataset. This does not indicate that those airlines did not comply with biosecurity requirements; rather, it indicates that this issue was not explicitly emphasised within the airline documents analysed. Similarly, variation in Stakeholder Collaboration reflects differences in the extent to which organisational reports documented partnerships and stakeholder engagement.

The comparison therefore needs to be interpreted in relation to the documentary nature of the dataset. Differences in coded-reference counts may reflect organisational reporting priorities, the amount of detail contained within individual reports, and the type of information publicly disclosed rather than direct differences in sustainability performance. Nevertheless, the comparison shows that the five airlines placed different documentary emphasis on sustainability strategy, food waste reduction, resource efficiency, waste management, collaboration, and regulatory issues. These patterns complement the thematic findings presented in Sections 4.3–4.10 and demonstrate the different organisational priorities evident across the five airline cases.

Table 4.1 Cross-Case Comparison of Parent Themes Across the Five Airlines

Main Theme	Air New Zealand	China Southern	Emirates	Qantas	Singapore Airlines
Waste Management Practices	3	9	5	6	4
Stakeholder Collaboration	0	5	3	4	4
Biosecurity Compliance	0	5	0	1	1
Resource Efficiency	0	9	8	5	5
Food Waste Reduction	3	3	8	2	3
Sustainability Strategies	5	9	5	6	8
Circular Economy	3	3	7	3	2
Regulatory Constraints	2	2	3	3	3
Total References	16	45	39	30	30

Note: The values represent distinct documentary extracts coded to each parent theme in NVivo. A single section of a document could contain more than one coded reference where separate extracts addressed different aspects of a theme. Higher values therefore indicate greater prominence of that theme within the analysed documentary evidence rather than the frequency of a particular phrase or the performance of an airline.

4.12 Chapter Summary

This chapter presented and discussed the findings from the thematic analysis of documentary evidence across the five airline cases. Eight key themes were identified: Food Waste Reduction, Circular Economy, Sustainability Strategies, Waste Management Practices, Biosecurity Compliance, Regulatory Constraints, Stakeholder Collaboration, and Resource Efficiency. The findings demonstrated that

airlines are adopting a range of sustainability and waste management initiatives, although the emphasis and implementation of these practices varied across the cases.

The cross-case analysis further highlighted the interaction between organisational sustainability objectives, operational practices, and regulatory requirements. While the findings demonstrated opportunities for waste prevention, resource efficiency, recycling, and other Circular Economy practices, New Zealand's biosecurity requirements continue to influence how ICW can be managed, treated, and recovered. Overall, the findings demonstrate that achieving more sustainable in-flight food waste management requires a balance between organisational sustainability initiatives, operational feasibility, stakeholder collaboration, and biosecurity compliance. These findings provide the basis for the conclusions and recommendations presented in Chapter 5.

Chapter 5: Conclusion

5.1 Introduction

This chapter presents the conclusions of the study by synthesising the key findings and demonstrating how they address the research aim and research questions. The study examined how major airlines operating direct international flights to Auckland manage in-flight food waste within New Zealand's biosecurity framework and explored how these practices align with broader sustainability and Circular Economy objectives. To achieve this aim, the study adopted an interpretivist qualitative comparative multiple-case study design and analysed secondary documentary evidence from airline sustainability reports, annual reports, regulatory publications, airport documents, and industry guidance. The findings presented in Chapter 4 identified eight interconnected themes that provide the basis for answering the research questions. The remainder of this chapter revisits each research question, discusses the theoretical and practical contributions of the study, outlines its limitations, and provides recommendations for future research.

5.2 Response to Research Questions

Research Question 1: How do major international airlines operating direct flights to Auckland manage in-flight food waste within the constraints of New Zealand's biosecurity regulations?

The findings indicate that major international airlines operating direct flights to Auckland manage in-flight food waste through an integrated combination of food waste reduction initiatives, waste management practices, sustainability strategies, resource efficiency measures, and strict biosecurity compliance. Across the five airline cases, a range of approaches was identified, including meal forecasting, inventory optimisation, waste monitoring, sustainable packaging, waste segregation, and operational efficiency, although the emphasis placed on these practices varied between airlines. These initiatives demonstrate that airlines increasingly prioritise waste prevention at source rather than relying solely on downstream waste treatment. At the same time, airlines operating international services to Auckland are required to comply with New Zealand's biosecurity requirements governing ICW, which influences procedures for its collection, transportation, treatment, and disposal.

Overall, the findings demonstrate that effective in-flight food waste management within New Zealand depends on balancing operational efficiency and sustainability objectives with strict compliance with the country's biosecurity regulations.

Research Question 2: In what ways do these biosecurity requirements shape airline strategies for waste reduction and disposal?

The findings demonstrate that New Zealand's biosecurity requirements play a significant role in shaping airline strategies for in-flight food waste reduction and disposal. While sustainability initiatives such as

waste prevention, resource efficiency, and sustainable packaging were evident across the airline cases, their implementation occurred within the regulatory environment governing ICW. The cross-case analysis showed that biosecurity regulations require airlines to follow controlled procedures for the collection, transportation, treatment, and disposal of catering waste, limiting opportunities for food redistribution, composting, recycling, and other Circular Economy practices. Within these constraints, waste prevention at source through improved meal forecasting, inventory management, and operational efficiency provides an important approach to reducing the volume of waste requiring regulated disposal. Overall, the findings indicate that biosecurity requirements do not prevent airlines from pursuing sustainability objectives but significantly influence how these objectives are achieved within New Zealand's regulatory environment.

Research Question 3: What opportunities exist for aligning compliance obligations with sustainability and Circular Economy objectives in the context of International Catering Waste?

The findings indicate that opportunities exist to strengthen the alignment between biosecurity compliance and sustainability objectives through greater collaboration, innovation, and resource efficiency across the aviation sector. Although New Zealand's biosecurity regulations restrict practices such as food redistribution, composting, and recycling of ICW, the study identified several opportunities to support Circular Economy principles within these regulatory constraints. These include improving meal forecasting, reducing food waste at the source, adopting sustainable packaging, enhancing waste segregation, increasing resource efficiency, and strengthening collaboration between airlines, airports, catering providers, waste management companies, regulators, and industry organisations. The findings suggest that technological innovation and coordinated stakeholder engagement can support more sustainable food waste management while maintaining New Zealand's high biosecurity standards. Overall, the study concludes that greater alignment between compliance obligations and sustainability objectives is achievable through continuous operational improvement and collaborative approaches that balance environmental goals with regulatory requirements.

5.3 Contributions of the Study

This study contributes to both academic knowledge and professional practice by examining how major international airlines operating direct flights to Auckland manage in-flight food waste within New Zealand's biosecurity framework while pursuing broader sustainability and Circular Economy objectives. By addressing the three research questions, the study provides insights into the relationship between regulatory compliance, sustainability strategies, and food waste management within the context of international airline operations in New Zealand. In the following, the contributions of this study are discussed in greater detail under theoretical and practical contributions.

5.3.1 Theoretical Contributions

This study contributes to the academic literature by extending understanding of sustainable in-flight food waste management within the context of New Zealand's biosecurity framework. While previous studies have examined aviation sustainability, food waste management, Circular Economy principles, and biosecurity requirements, limited research has considered these areas together within the context of international airline operations under New Zealand's biosecurity framework. By applying the Circular Economy framework to a qualitative comparative multiple-case study of airlines operating direct international flights to Auckland, the study demonstrates how regulatory requirements interact with sustainability initiatives and shape opportunities for more circular approaches to food waste management. Furthermore, the research demonstrates that achieving sustainable in-flight food waste management requires balancing environmental objectives with mandatory biosecurity compliance, thereby contributing to a more integrated understanding of sustainability within highly regulated aviation environments.

These theoretical contributions build upon existing Circular Economy scholarship, which emphasises waste prevention, resource efficiency, and the retention of material value within production and consumption systems (Kirchherr et al., 2017; Geissdoerfer et al., 2020). Blomsma and Brennan (2017) and Korhonen et al. (2018) further highlight the importance of understanding the organisational and systemic conditions that influence the implementation of Circular Economy principles. Within aviation, Blanca-Alcubilla et al. (2019) and Salesa et al. (2023) provide an academic foundation for examining airline cabin waste generation and sustainable waste management practices. Building on this scholarship, the present study contributes a context-specific understanding of how biosecurity requirements influence the application of Circular Economy principles to international catering waste. In particular, the findings suggest that waste prevention and resource efficiency may offer more immediately applicable opportunities for airlines where regulatory requirements restrict downstream recovery options. This extends the discussion of Circular Economy implementation by demonstrating the importance of considering regulatory conditions alongside environmental and operational objectives.

5.3.2 Practical Contributions

This study provides several practical contributions for airlines, airports, catering providers, waste management companies, regulators, and industry organisations involved in managing ICW. The findings indicate that integrating food waste prevention, resource efficiency, stakeholder collaboration, and biosecurity compliance into operational decision-making can support more sustainable in-flight food waste management. The study highlights the importance of strategies such as improved meal forecasting, inventory optimisation, sustainable packaging, waste segregation, and data-driven resource management to reduce food waste while complying with New Zealand's biosecurity requirements. In

addition, the findings emphasise that stronger collaboration among industry stakeholders and regulatory agencies can support the development of waste management solutions that pursue environmental sustainability while maintaining New Zealand's biosecurity requirements. These practical insights can assist organisations in strengthening sustainability strategies, improving operational efficiency, and informing future policy and decision-making for the management of ICW.

Based on these findings, several practical actions are recommended for airlines operating international services to Auckland. First, airlines could strengthen meal-demand forecasting by using historical passenger consumption data, pre-order information, and route-specific demand patterns to reduce unnecessary meal loading. Second, catering teams could implement standardised procedures for recording surplus meals, food waste quantities, and recurring sources of waste to support regular monitoring and operational improvements. Third, airlines could work with catering suppliers to review portion sizes, optimise inventory management, and reduce unnecessary packaging through the use of lighter and more resource-efficient materials. Fourth, airlines could introduce clearer onboard waste-segregation procedures and provide crew training to distinguish between different waste streams, ensuring that any separation, handling, or recovery of international catering waste remains consistent with applicable biosecurity requirements. Fifth, airlines could establish regular coordination meetings with airport operators, catering providers, approved waste contractors, and relevant regulatory authorities to identify feasible waste-reduction initiatives and assess any proposed recovery or treatment options before implementation. Finally, airlines could incorporate measurable food waste reduction targets and periodic performance reviews into their sustainability programmes to monitor progress and support continuous improvement. Together, these actions provide practical opportunities to reduce waste generation while maintaining compliance with New Zealand's biosecurity requirements.

5.4 Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the research relied exclusively on secondary documentary sources, including airline sustainability reports, annual reports, regulatory publications, airport operational documents, and industry guidance. As these documents were produced for organisational and public communication purposes, they may emphasise successful sustainability initiatives while providing limited insight into operational challenges or internal decision-making processes. Second, the study focused on five major international airlines operating direct international flights to Auckland. Although these cases provided valuable comparative insights, the findings may not be representative of all international airlines or of airlines operating under different regulatory or biosecurity frameworks. Finally, the qualitative comparative multiple-case study approach was designed to provide an in-depth understanding of organisational practices within the selected cases rather than statistically generalisable findings. Consequently, the findings should be interpreted within the context of the selected airline cases and New Zealand's biosecurity environment.

5.5 Recommendations for Future Research

This study provides a foundation for future research on sustainable in-flight food waste management within international airline operations. Future studies could build on these findings by incorporating primary data collection methods, such as interviews or focus groups with airline managers, catering providers, airport operators, waste management companies, and regulatory authorities, to gain deeper insights into the operational challenges and decision-making processes associated with ICW. Comparative research involving airlines operating in different countries or under alternative biosecurity frameworks would also provide a broader understanding of how regulatory environments influence sustainable food waste management practices. In addition, future research could examine the application of emerging technologies, including artificial intelligence, digital waste monitoring systems that record and analyse the type, quantity, and source of waste generated, and innovative waste treatment solutions, to evaluate their potential for identifying waste-reduction opportunities, improving resource efficiency, and supporting biosecurity compliance. Such research would further strengthen understanding of how sustainability and Circular Economy principles can be integrated into international airline catering operations.

5.6 Overall Conclusion

This study examined how major international airlines operating direct international flights to Auckland manage in-flight food waste within New Zealand's biosecurity framework and explored how these practices align with broader sustainability and Circular Economy objectives. The findings demonstrate that effective food waste management extends beyond waste disposal to encompass food waste prevention, resource efficiency, stakeholder collaboration, and broader organisational sustainability strategies. While sustainability initiatives aimed at reducing environmental impacts were evident across the five airline cases, the study also showed that New Zealand's stringent biosecurity regulations play a significant role in shaping the implementation of sustainable waste management practices, particularly by limiting opportunities for food redistribution, recycling, composting, and other Circular Economy initiatives.

The cross-case analysis identified different areas of emphasis among the five airlines. Air New Zealand's documentary evidence emphasised sustainability strategy and food waste and waste management initiatives, while China Southern Airlines demonstrated a strong focus on resource efficiency, waste management, and sustainability strategies. Emirates showed particular emphasis on food waste reduction, resource efficiency, and Circular Economy initiatives. Qantas demonstrated a comparatively balanced approach across sustainability strategy, waste management, resource efficiency, and stakeholder collaboration, while Singapore Airlines placed strong emphasis on sustainability strategy alongside resource efficiency and stakeholder collaboration. These differences reflect the

priorities evident within the documentary evidence analysed and should not be interpreted as a ranking of airline sustainability performance.

Despite regulatory constraints, the research identified opportunities to strengthen sustainable food waste management through improved operational practices, technological innovation, resource efficiency, and greater collaboration between airlines, airports, catering providers, waste management companies, regulators, and industry organisations. By integrating the Circular Economy framework with a qualitative comparative multiple-case study approach, this research contributes to understanding how sustainability objectives can be pursued within a highly regulated aviation environment. Overall, the study demonstrates that achieving more sustainable in-flight food waste management depends on balancing environmental aspirations with biosecurity compliance through coordinated, innovative, and evidence-based approaches that support both national biosecurity protection and long-term sustainability objectives.

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