A conceptual framework for the adoption of e-logistics technologies: Towards improved data analytics practice in the Western Cape fishing industry

Bradley Bucky Khumalo

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Supervisor: Professor Shaun Pather

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Plagiarism Declaration

Declaration

Hereby I, Bradley Bucky Khumalo, declare that *“A conceptual framework for the adoption of e-logistics technologies: Towards improved data analytics practice in the Western Cape fishing industry”* is my original work and that all sources have been accurately reported and acknowledged, and that this document has not previously in its entirety or part been submitted at any university to obtain an academic qualification.

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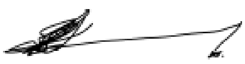
Signature:  ______________________

Approved by

Supervisor name

Main Supervisor

…………………….

Abstract

E-logistics technologies to enhance supply chain efficiencies and improve data analytics across nations and industries continue to be developed. These provide the capacity and capability to enable timely, accurate and readily accessible data analytics at low cost and greater efficiencies. The abundance of these technologies has not translated to increased e-logistics technology adoption in the local fishing industry. Instead, the industry continues to use, as part of its operations, outdated methods of data collection resulting in frequently inaccurate and incoherent analyses. While quantitative fisheries management has significantly improved, data analytics has remained a challenge. Consequently, there have been numerous calls for the adoption and implementation of e-logistics technologies which would improve data analytics capabilities, complementing quantitative fisheries management interventions. The main factors influencing the adoption of these technologies have been researched in various industries, yet not many studies are presented relating to the fishing industry. The aim of this study, thus, was to understand factors that influence the adoption of e-logistics technologies that would, in turn, facilitate the development of data analytics in the fishing industry. The primary research question was: *"What are the primary factors influencing the adoption of e-logistics technology in Western Cape fishing organisations?"*. The research investigated these factors using an amalgamated Technology-Organisation-Environment (TOE) and the Diffusion of Innovation (DOI) framework. Data was collected through interviews and an online survey, and the qualitative data were analysed to present an e-logistics technology adoption framework for the Western Cape fishing industry. The findings indicate that relative advantage, compatibility and security are primary technology adoption factors. Additional primary adoption factors include organisation factors of top management and absorptive capacity and environment factors of government regulation and partnerships amongst all stakeholders. Based on these findings, an e-logistics technology adoption framework was developed for the fishing industry. The framework synthesises the key findings. It presents an overview of the key constructs and the associated inter-relationships between them. The framework serves as a contribution to the literature. It furthermore serves to inform stakeholders in the fishing industry on the main elements in relation to how e-logistics technologies, legislation, and other socio-economic factors interplay.

Keywords:

data analytics, Diffusion of Innovation (DOI) Framework, e-logistics, fishing industry, technology adoption, Technology-Organisation-Environment (TOE) Framework

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Dedications

This mini-thesis is dedicated to my late sister, Blessings Karen Ndiweni, who celebrated my enrolment and would have loved to witness my graduation too. We started the journey together but did not finish it together, yet I know you would have prayed for me and supported me until the very end. It is a small token, yet one filled with life, love, hope, purpose, and gratitude. A better day shall rise.

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Key terms and concepts

4IR	Fourth Industrial Revolution
Data Analytics	The science of obtaining and analysing raw data to provide meaningful insights and draw data-informed conclusions.
DOI	The Diffusion of Innovation framework for technology adoption developed by Rogers (1962).
e-Logistics	The paper-to-digital technologies that improve an organisation's data logistics.
FAO	Food and Agriculture Organisation of the United Nations
Fisheries Management	It is often seen as the solution to "tragedies of the commons" and refers to resource conservation, economic implications of alternative management strategies and the social context within which management decisions are developed and implemented (Fogarty & Collie, 2019; Wilson & McCay, 2019).
IoD	Internet of Data
IoP	Internet of People
IoS	Internet of Services
IoT	Internet of Things
Technology Adoption	The decision to use or to implement a technology (Ifejika, et al., 2008).
TOE	The Technology Organisation Environment framework developed by Tornatzky & Fleischer (1990) incorporates various aspects influencing technology adoption both within and outside of organisations or individuals.
SDGs	United Nations Sustainable Development Goals
Supply Chain	A network of organisations or stakeholders supported by three pillars of processes, including a firm's logistics capability, organisational structures and enabling technologies (Wagner & Sweeney, 2010).

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Chapter 1: Introduction and Background to the Study

1.1 Background to the Research Problem

To maintain competitive organisations in their respective industries, business leaders have adopted various tools, approaches and technologies, setting up systems for improved performance and monitoring results and growth (Schnegg & Möller, 2022). Amongst the resources used is data to foster data-driven decision-making in organisations. Hartmann, Zaki, Feldmann & Neely (2016) note that data is the new oil. It is a currency that enables business operations to be more efficient (Siefkin, 2018). Thus, data and data analytics in organisations play a crucial role in ensuring business profitability and continuity. In particular, organisations need data relating to their customers, employees, environment and the products within their supply chain to make informed decisions towards improved operations, increased profitability and business continuity (Kubina, Vamus & Khubinova, 2015). It is anticipated that as more data are collected and more technologies developed, data generation and communication through machines over vast data networks will continue to grow exponentially (Sivarajah, Kamal, Irani & Weerakkody, 2014; Van Dijck, 2014).

Data analytics, a concept building on the availability of data, is the science of analysing raw data to draw conclusions and involves the process of inspecting, cleansing, transforming and modelling data and applying algorithms to draw insights from the data, including identifying previously unknown patterns (Frankenfield, 2020; Elgendy & Elragal, 2014). Organisations ought to innovate, develop and improve with changing customer demands and preferences, changing marketplaces, structures and dynamics, and the continual growth opportunities presented by technologies (Duan, Cao & Edwards, 2018; Baregheh, Rowley & Sambrook, 2009). The innovation activities of these organisations and industries depend on the use and analysis of data, including the investment into data capabilities in terms of human capital and data infrastructure (Yan, Xia, Li & Huang, 2023; Melville, Karemer & Gurbaxani, 2004; Dewan & Min, 1997). As such, organisations need to collect and analyse data, transform the data into information, information into knowledge, knowledge into insight and insight into action that leads to improved operational procedures (Whitelock, 2018). Organisations thus become engaged in continual development that enables the realisation of value across the entire data process and business value chain. Regardless of this reality, some sectors are grappling with how to enrich data and data analytics in their ways of working. Among these is the fishing industry, where the technologies to improve data analytics are being adopted at a slow rate (Girard & Du Payrat, 2017; Mills, Westlund, De Graaf, Kura, Willman & Kelleher, 2011).

1.2 Background to the Fishing Industry

The slow rate of adoption should be considered against the growing rate of the negative environmental realities resulting from overfishing. According to the Food and Agriculture Organisation of the United Nations (2020), between 1990 and 2017, fish stocks within biologically sustainable levels dropped from 90% to 65.8%. Yet, fish consumption for food increased by 122% and continues to do so with a growing global population (Food and Agriculture Organisation of the United Nations, 2020). It now takes up to five times the kilowatt-hour to catch the same number of fish as in 1950 (Christiani, Claes, Sandnes & Stevens, 2019). Figure 1 displays the wild-fish capture trend globally, showcasing the over-exploited and collapsed fisheries state.

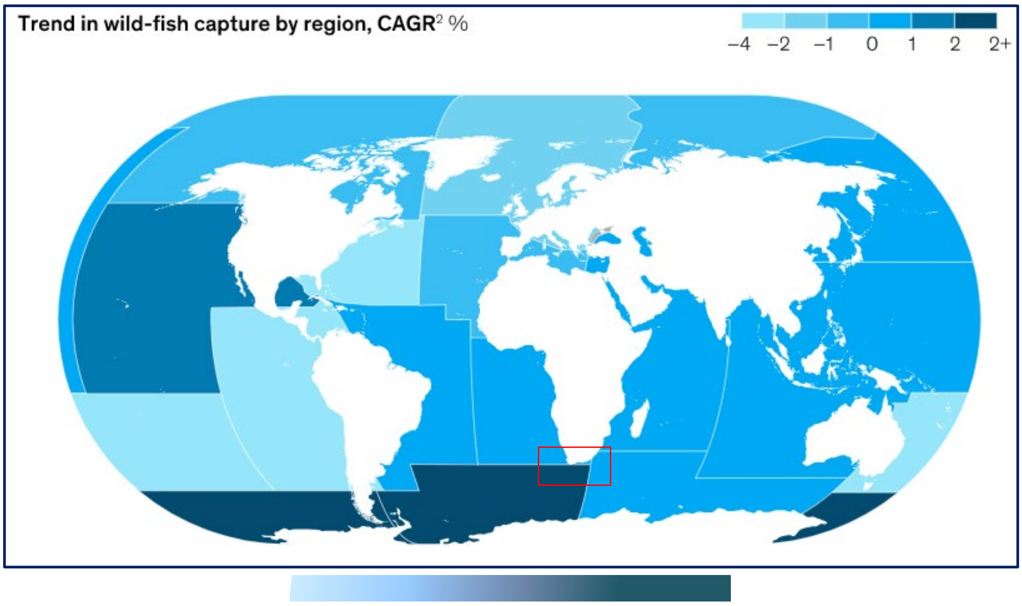


Figure 1: Global Wildfish Capture [Source: Christiani et al. (2019) – under-exploited (light blue) to over-exploited and collapsed fisheries (dark blue)]

Amongst the most exploited (dark blue areas) are fisheries close to the South African coastline. Seafood contributes US$362 billion annually to the global economy and about 600 000 tonnes of fish worth R6 billion in South Africa, with the industry contributing about 0.1% of the South African economy (Department of Environment, Forestry and Fisheries (DEFF), 2020). Although the percentage contribution is small, the nation's rural economy depends immensely on its viability and continuity (World Fishing and Aquaculture, 2013). South Africa has over

3 000 km of coastline. It is a net exporter of fish and fish products with estimated industry employment at 27 000 jobs and an additional 81 000 – 100 000 indirect jobs linked to the industry (Brick & Hasson, 2020).

The depletion of wild fish stocks and the importance of the fishing industry both in South Africa and globally against the development of technology and the limited adoption of data analytics technologies necessitate e-logistics interventions to better manage the supply chain and ensure the future sustainability of the industry. There is growing pressure, amongst other interventions, to promote innovation and sustainability and, thus, improve marine environment management (Rowan, 2022; Hilborn, Amoroso, Anderson, Baum & Branch, 2020). Part of the innovation available includes e-logistics technologies. These enable and enhance data analytics in the business, including the potential to reduce costs and risks for both marine resources and the fishing industry (Barkai, Felaar, Geggus, Dantie & Hayes, 2012). These technological advances allow for improved monitoring and control of fishing, more data collected, shared and analysed across the industry supply chain and an overall improvement of fisheries science and the overall ecosystem (Girard & Du Payrat, 2017). Improvements additionally include organisations' bottom line by increasing productivity, reducing costs, improving profitability and thus, addressing the scourge of poverty that is prevalent in the developing world (Mazuki, Osman, Bolong & Omar, 2020).

E-logistics refers to applying the latest information technologies to support logistics management (Dębkowska, 2017). A key benefit of e-logistics is the collect once, use many times concept (Merrifield, Gleason, Bellquist, Kauer, Oberhoff, Burt, Reinecke & Bell, 2019; Barton, Kallem, Van Dyke, Mon & Richesson, 2011). Other benefits include time savings, improved operational efficiency, supply chain coordination, intralogistics management (Kanagavalli, 2019) and, thus, overall improved data and data analytics use. Information technology enables organisational success by improving internal processes, improving revenue prospects, lowering costs and improving profitability (Elazhary, Popovič, de Souza Bermejoc & Oliveira, 2023).

The development of fisheries and adoption of fisheries technologies, therefore, requires a multi-disciplinary, multi-faceted approach seeking to understand complexities as they relate to different stakeholders with differing world views (Smidt, 2021; Jokonya, 2016). The e-logistics technologies have the potential to build industry data literacy and further enrich data analytics and the management of fisheries thereof.

1.3 Research Problem

Although managing every digital supply chain and various information flows are imperative, many organizations cannot take advantage of the continual fast-paced technological advances (Wang & Pettit, 2016). While there are several new technologies and systems to support data analytics and associated business intelligence and data governance initiatives, Diaz (2020) notes that the adoption and implementation of these technologies and systems are still lacking in the fishing industry. The industry exhibits poor management of data from the source to the data end-user in that, while fisheries management quantitative methods have developed well, a major obstacle remains in the absence of quality data to enable fisheries management (Diaz, 2020). Historical data are absent and, in some instances, an absence of present data for future use from the use of paper logbooks and other excel files that may be corrupted or lost or may be difficult to use or contain incorrect data (Diaz, 2020). Managing fisheries sustainably in an era of uncertainty and climate change requires modernised fisheries data systems from the source of the data through the data chain to the end-user of the data throughout the supply chain (Merrifield, et al., 2019).

This research acknowledges the need for modern data systems. It recognises that e-logistics technology adoption challenges facing organizations are too complex to be resolved using only one approach as there is no one-size-fits-all solution (Jokonya, Kroeze & Van der Poll, 2014). The study, therefore, investigated the primary factors that promote e-logistics technology adoption to enable data analytics in the Western Cape fishing industry.

1.4 Research Objective

The research objectives seek to answer the question: *"What are the primary factors influencing the adoption of e-logistics technology in Western Cape fishing organisations?"* The following objectives were developed to align with key research milestones in the study:

1. To identify the e-logistics technologies for data analytics within the fishing industry.
2. To identify conceptual frameworks that provide a suitable lens to investigate e-logistics technology adoption in the fishing industry in the Western Cape.

3. To design a research instrument, based on the identified conceptual framework to collect data to probe the research problem.
4. To identify the primary factors that affect e-logistics technology adoption in the Western Cape fishing industry.
5. To synthesise the findings into a framework to promote the adoption and implementation of data analytics enabling e-logistics technologies in the Western Cape fishing industry.

Table 1 summarises the research objectives, sub-questions and methods for answering the identified research question.

Table 1: Research question, sub-questions, methods and research objectives alignment

Research Question: What are the primary factors influencing the adoption of e-logistics technology in Western Cape fishing organisations?		
Sub-Question	**Methods to pursue Objective**	**Objectives**
What types of e-logistics technologies support data analytics in a typical fishing context?	Literature Review	To identify available e-logistics technologies for data analytics within the fishing industry.
What frameworks are relevant to understanding technology adoption in a fisheries context?	Literature Review	To identify conceptual frameworks that would provide a lens to investigate technology adoption in the Fishing industry in the Western Cape.
How does the selected framework inform and develop into the interview instrument?	Instrument design	To use the identified conceptual technology adoption framework to design a suitable research instrument to inform research activities.
What factors influence e-logistics technology adoption for data analytics in the fishing industry?	Fieldwork Quantitative & Qualitative analysis of data	To identify factors that affect e-logistics technology adoption for data analytics in the fishing industry.
What are the key elements of the conceptual framework regarding technology adoption to support data analytics in the fishing environment?	Interpretation of findings	To develop a conceptual framework to support the implementation of data analytics enabling e-logistics technologies in the fishing industry.
How are the key elements of the framework regarding technology adoption to support data analytics in the fishing environment inter-related?	Interpretation of findings	To develop a framework to support the implementation of data analytics enabling e-logistics technologies in the fishing industry.

1.5 Delineation: The Scope of Study

Technology adoption has been studied in various industries and geographic locations for many years. This research considers previous technology adoption studies and frameworks both in the fishing industry and in other industries globally to develop a conceptual framework for the fishing industry in the Western Cape of South Africa. The research was conducted amongst fishing organisations operating within the Western Cape. The organisations were involved in the operational activities of the industry both onshore and offshore, including associations for specific commercial fisheries. The technologies considered in the research are those technologies with the potential to improve data analytics by digitising some or all possible aspects of the fishing supply chain and providing safe, reliable data collection, data movement, data storage, data sharing and data analyses as needed in fisheries management. Further discussions on the technologies considered, the fishing industry logistics, the history of adoption studies and the research's unit of analysis are in Chapter 2 and Chapter 3 respectively.

1.6 Significance of the Study

The research contributes towards the realisation of United Nations Sustainable Development Goals (SDGs) SDG9 (Industry, Innovation and Infrastructure) by promoting inclusive innovation, SDG12 (Responsible Consumption and Production) by encouraging the use of more efficient data analytics processes and SDG14 (Life Below Water) by encouraging sustainable fishing (United Nations, 2023). The movement of many operations from paper to digital platforms and the adoption of e-logistics technologies characterise the current Fourth Industrial Revolution (4IR) trends. As modern technologies are adopted, data may be collected and analysed in a timely and secure manner. Fishing targets may be objectively set and efficiently monitored, improving the efficacy of governance and rules enforcement in the fishing industry. Concurrently, catch productivity and profitability in fishing organisations may improve, while poaching and other illegal fishing activities decrease. Adopting these technologies may be a catalyst for solving global fishing crises by enabling the transformation of fisheries practices and policies as noted by Ortiz (2019). E-logistics technology use ought to be encouraged. To encourage the use, adoption-influencing factors ought to be investigated, this being the objective of this research.

The research will contribute to e-logistics technologies adoption studies with a specific focus on the fishing industry. This expands the knowledge and understanding of the processes related to future digitisation innovations and initiatives by the government and fishing organisations whilst also providing a framework from which fishing technology companies may develop future technology adoption initiatives. As Info-Tech Research Group (2021) notes, developing industry-specific models that organisations can tap into is more cost-effective and time-saving.

The Western Cape is a majority fish industry contributor to the South African economy in terms of both Gross Domestic Product from fisheries and employment (Brick & Hasson, 2020). Investigating the Western Cape provides an understanding of a sizeable proportion of South African fisheries, laying a sound foundation for future studies in the fishing industry's information technology adoption and continued use. Furthermore, this research complements sustainable fishing and fisheries management efforts, including innovative interventions for fisheries management, contributing to the fishing technologies' adoption body of knowledge.

Fujita et al. (2018) note that while technologies generate data, people make sense of and use it. The authors (ibid) further note that people find the right technology and purchase, install, test, maintain and repair the technology. This research acknowledges the pivotal role people play in e-logistics technology adoption, and the use and benefit-realisation of e-logistics technologies for data analytics.

1.7 Layout of the Thesis

Chapter 1 discusses the background and setting within which the research is being undertaken. We discuss the prevalent fisheries and e-logistics technologies trends to inform the research objectives.

In Chapter 2, we introduce the literature review related to the identified research question of "*What are the primary factors influencing the adoption of e-logistics technology in Western Cape fishing organisations?*". We provide a summary of the fishing industry trends as they relate to technology adoption, introduce data analytics and the solutions possible as they improve and provide a summary of technology adoption frameworks used in many technology adoption studies. We conclude the Chapter by developing and customising two available adoption frameworks to better capture the research question and objectives.

Chapter 3: provides the research methodology applied toward an e-logistics technology adoption framework for the fishing industry development. The chapter includes the research paradigm adopted, the research design, the research population, the data collection and analysis steps and the ethical considerations made. The online survey and interview research questions are provided in Appendices A and B.

In Chapter 4, the research outcomes are discussed. The chapter includes findings related to the adopted TOE-DOI framework and new concepts identified as pertinent to e-logistics technology adoption. Additionally, the chapter includes verbatim responses where necessary, a comparison of the online survey and interview outcomes and discussions relating to this research's findings compared to other studies in other countries and industries.

Chapter 5 concludes the research and provides a framework for adopting e-logistics technologies toward improved data analytics practice in the Western Cape fishing industry. The chapter includes the evaluation of the set-out objectives against the research outcomes, includes the contribution of the research, provides a reliability and validity statement, concluding with the limitations of the research and the recommendations thereof. Figure 2 summarises the layout of the thesis.

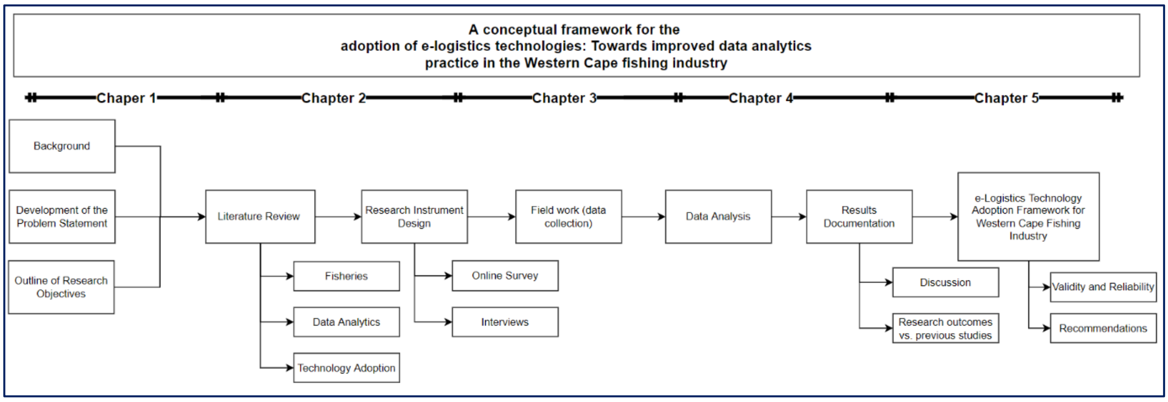


Figure 2: Layout of the thesis

1.8 Chapter Summary

This chapter introduces the research question and provides the fishing industry and e-logistics technology adoption background. This background informs the research problem, question, sub-questions, and objectives. Once defined, the scope of the study is discussed, informing the significance of the research. The chapter identifies five research objectives and outlines methods to reach these successfully. E-Logistics technology adoption for improving Western Cape fishing companies' data analytics is explained as being at the centre of the research. The chapter concludes with an outline of the thesis.

Chapter 2: Literature Review

2.1 History of Fisheries Technology and Supply Chain Management

Technological advancements are vital in developing an industry or an economy (Brey, 2018). These advances have continually played a pivotal role in the development of various industries including the fishing industry (Love, 2010). The agricultural and industrial revolutions, Love (2010) continues, saw the development of bigger-sized boats, farther travel possibilities, sophisticated fishing methods and gear development, yet, the industry has remained at the mercy of uncertainties as before the technological advances. Food and Agriculture Organisation FAO (2009) further noted that these technologies have advanced over the last century, enabling increases in vessel sizes and production methods to harvest more fish. Technological developments during the period included the development of fish-finding devices, fish-storage facilities on fishing vessels, development of vessel monitoring systems (VMS) and other satellite communication, Fish and Fishing Monitoring and Compliance technologies and the currently ongoing fourth industrial revolution advances. The development of these technologies continues to play a vital role in reaching sustainable fishery resource management and the adoption thereof becomes imperative to manage the uncertain realities of the fishing industry (Fujii, Sakakura, Hagiwara, Bostock, Soyano, & Matsushita, 2018. Considerations are made within the entire fishing industry's supply chain.

A supply chain refers to the process that seeks to manage and coordinate all activities, from upstream sourcing and acquisition to production, to the distribution channels, and up to the downstream end customer (Quayle, 2006). Supply chain management, at its core, is interested in integrating activities within and between organisations (Wagner & Sweeney, 2010). Ambe & Badenhorst-Weiss (2012), citing Lambert (2006), note that although supply chain management definitions differ, supply chain management may be classified into three categories: a management philosophy, the implementation of the philosophy and a set of management processes. The authors (ibid) further state that supply chain management may be applied in different industries and sectors. They note that a supply chain is a formation of a value chain network consisting of functional entities committed to the controlled sharing of business data and processes. As such, supply chain management in fisheries includes numerous stakeholders from the government, fishing operations companies, fishing technology companies, scientists and the consumers of the fish products.

Although primarily similar to other forms of management, fisheries management is unique and complicated in that it is often uncertain or within an uncertain environment (Bentley & Stokes, 2009). The Covid-19 pandemic crisis further accelerates this, where there have been numerous supply chain shocks, lifestyle and supply chain reconfigurations, ongoing environmental concerns and fisheries stock depletion exacerbated by increased fish food demand (Food and Agriculture Organisation of the United Nations, 2020). Fisheries management is often seen as the solution to "tragedies of the commons" (Wilson & McCay, 2019). It refers to resource conservation, the economic implications of alternative management strategies and the social context within which management decisions are developed and implemented (Fogarty & Collie, 2019). To avert the demise of the environment while enhancing revenue and profits for organisations, data analytics is used to inform fisheries science and management, the monitoring and compliance governance, and the development of related policies, enabling the overall marine environment management. It is imperative to ensure that fishing as an activity is sustainable as it becomes more predictable, more efficient and, therefore, more profitable and beneficial to society over the long term. Data and the collection of data through relevant systems and technologies become major enablers of such a future (Bradley, Merrifield, Miller, Lomonico, Wilson & Gleason, 2019). Data, the new currency of business, provides opportunities for process improvements, efficiency increases, revenue growth and overall business sustainability (Siefkin, 2018). Fishing data can potentially improve fisheries management and supply chain, eliciting the need to understand and adopt technologies that enhance these data collection and analysis.

2.1.1 Overview of the Western Cape Fishing Industry

The Western Cape has 11 of the proclaimed 13 national fishing harbours, which contribute 5% to the province's Gross Domestic Product (GDP) (Food and Agriculture Organization of the United Nations (FAO), 2018).

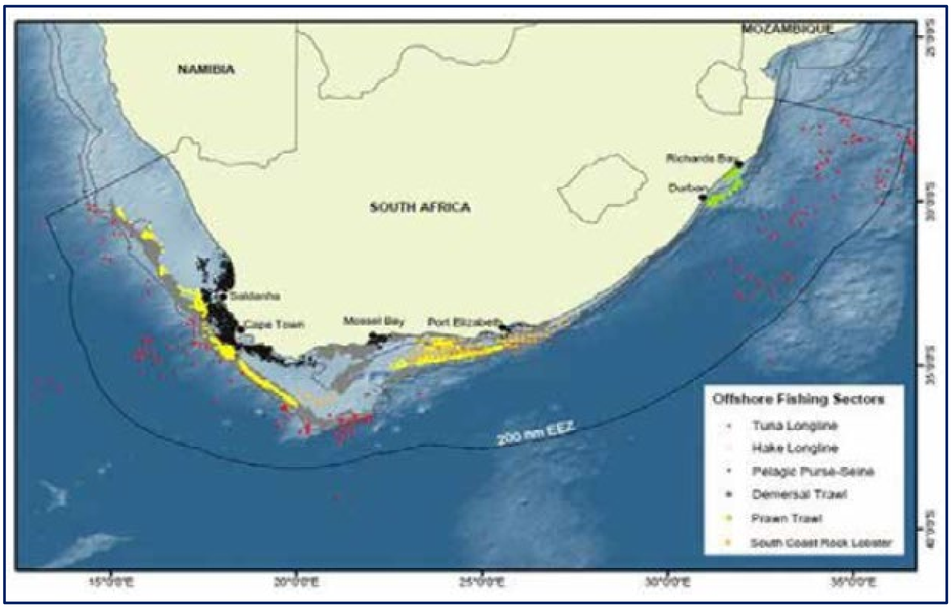


Figure 3: Distribution of main commercial fisheries in South Africa with main fishing harbours. (Source: Food and Agriculture Organization of the United Nations (FAO) 2018)

The province is estimated to contribute about 72% of fisheries industry income and provide 71% of industry employment, providing about 85% of South Africa’s total fish exports in 2012 (Brick & Hasson, 2020). The Western Cape Government Environment Affairs and Development Planning (2018) note that 50% of commercially exploited species in the Western Cape are either over-exploited or collapsed, thus needing urgent interventions. An ecosystem-based management approach that considers the conservation of the environment, the sustainability of the fishing industry and the availability of the needed fish food becomes necessary in tandem with other management philosophies. As Kamilaris, Kartakoullis & Boldú (2017) noted, this approach considers biological, chemical, physical, ecological, economic and other social sciences implications to the management of agriculture and fisheries. Common across these sciences are data inputs, the management of the data and the technologies enhancing these data analytics.

OLRAC SPS (2013), in their report prepared for the Responsible Fisheries Alliance, notes that data collection and processes in the fishing industry in South Africa are cumbersome. They note, among many challenges, that paper logbooks, currently being used in many fisheries in South Africa, may carry irreconcilable errors, including a fisherman’s poorly written or recorded fishing activities. The author (ibid) notes these errors may be avoided by using electronic logbooks that, in turn, will accept both manual and automatically generated inputs where possible, preventing numerous manual entry errors. They further note that some fisheries in South Africa have as much as a two-year delay between the date of data recording and analysis by the fisheries scientists. The authors suggest considering international best practices in adopting electronic logbooks, part of the e-logistics technologies available in the fishing industry and developing central databases with controlled access to specific and targeted industry stakeholders. Electronic logbooks are an enabler of data analytics in their ability to automate data collection and securely store and transmit data for analysis. Although the OLRAC SPS study considered all South African fisheries, their findings are relevant to this research as the Western Cape is South Africa's fishing hub considering employment and economic contributions.

2.1.2 Supply Chain Management in the Fishing Industry

A supply chain is a network supported by three pillars of processes, including a firm's logistics capability, organisational structures and enabling technologies whose adoption is at the core of this research (Wagner & Sweeney, 2010; Akkermans, Bogerd, Yucesan & Van Wassenhove, 2003).

Fish is a common property resource and is thus considered prone to degradation and/or over-exploitation (Clark, 2013; Van Soest, 2013). The fishing industry supply chain comprises multiple players, including governments, fishing authorities and observers, private businesses, fishermen, fishing technology developers, the science community and fish consumers. The different stakeholders and supply chain actors manage and maintain fishing vessel fleets, provide fishing technologies, manage fishing trips and activities, manage data collection, report and analyse, and make, regulate and enforce fishing laws accordingly in an effort to provide fish and fish products to the relevant global customers and enable sustainable fisheries (FishSA, 2019; Barkai & Lallemand, 2014). The primary data sources and information for analysis include logbooks, catch-sampling programs, surveys and other monitoring systems like the Vessel Monitoring System (VMS) (National Research Council, 2000).

The upstream supply chain is unpredictable, while the downstream demand continues to grow, leading to uncertainties on both ends of the fishing industry supply chain (Hameri & Pálsson, 2003). The government of South Africa, through the Department of Forestry, Fisheries and Environment, manages fishing resources and is responsible for protecting, conserving and improving the South African environment and natural resources (South African Government, 2022). Effort control and vessel restrictions are some of the controls and restrictions enforced in most commercial fisheries through the Fishing Effort Allocation Committees (Food and Agriculture Organisation of the United Nations (FAO), 2021). Operational Management Procedures (OMPs) are followed in the main commercial fisheries. OMPs refer to agreed procedures between scientists, resource managers and the fishing industry based on the resource status (Kell, De Oliveira, Punt, McAllister, Kuikka, 2006).

2.1.3 From Traditional Logistics to e-Logistics in Fisheries

As part of this management process involving industry, science, government and consumers of the fish products, fishing vessels at sea communicate with relevant stakeholders and, in certain instances, have adopted Electronic Data Interchange (EDI) processes like XML file transfers for the exchange of data (Barkai, Meredith, Felaar, Dantie & De Buys, 2010). In contrast, others continue to use paper logbooks and phone calls as a communication and reporting method to relevant authorities (Barkai, et al., 2010). It is further noted by Barkai et al. (2010) that fisheries management is upset by a lack of data and or poor-quality data relating to fishing operations (catch, caught and predicted, and gear and other environmental data). The authors (ibid) further note that sometimes, the data collected by different stakeholders are stored in different locations, in complicated formats on computers and sometimes on paper, making timely analysis of the data a mammoth undertaking. Traditional logistics in the fishing industry rely on manual processes and limited technological integration. As has been noted, this results in fragmented data and resource inefficiencies. E-logistics on the other hand enable digital transformation, improve transparency and resource optimisation (Naseem & Yang, 2021). These in turn enable market integration and sustainability, improving overall fisheries management objectives. Future fishing vessels, therefore, ought to move from paper and pen to sensors and satellites (Fund, 2021).

E-logistics in fisheries is a comprehensive process that starts with data collection through various sensors, satellite tracking and on-board systems. This data collected is then transmitted to centralised platforms where advanced analytics are used to optimise routes, predict catch, predict demand and manage stocks. Research relating to the benefits of this transition from traditional logistics to e-logistics has included fishing-industrial logistics by Moiseenko & Meyler, (2017), e-logistics and the e-supply chain by Erceg & Sekuloska, (2019) and the internet-of-things-based decision support systems for green logistics by Mejjaouli, (2022). Benefits are highlighted with a caveat relating to the quality of data.

As the popular adage goes; garbage in, garbage out (also known as GIGO). Effective data analytics is only possible as accurate, timely and credible data are collected and utilised in analyses. Inadequate and untimely data and, in some instances, a complete loss of capability for data analyses to enable fisheries management thus hampers data analytics and sustainable fisheries management (Barkai & Lallemand, 2014). Diaz (2020) notes that fisheries data recorded on paper and spreadsheets are prone to various risks, including loss, manipulation, inaccuracy and general difficulty of use. It is not sufficient to continue with the status quo in managing data while technology developments continue to grow. The fourth industrial revolution presents opportunities to improve data capture, data transmission, data analyses and decision-making, thus improving fishing organisations' operations and profitability, government compliance and monitoring objectives and the overall industry's sustainability. Additionally, with the continued growth and development of the industry, Fisheries Monitoring Centres (FMCs) of the future will need to adjust from monitoring hundreds of vessels to tens of thousands, thereby requiring better monitoring and data management systems (Diaz, 2020). FMCs are centres that collect fishing vessels' data, validate and store them and subsequently make any relevant data available for analysis to relevant stakeholders (Girard & Du Payrat, 2017). Future steps in this light need to be informed as far as possible by the many aggregated observations possible and these need to be analysed and a strategy for improvement or mitigation defined, necessitating a study into primary factors influencing e-logistics technology adoption (Bellman, Rao & Ann, 2021).

Amongst the many available strategies for developing fisheries are the implementation of marine protected areas, the recording and monitoring of protected species, the reduction of by-catch species, monitoring and surveillance and other regulation measures (Kaur & Datta, 2021). To be efficient in the implementation of these requires the adoption of e-logistics technologies across the industry's supply chain.

At the core of this research is an understanding of the primary factors influencing the adoption of e-logistics technologies that have the potential to improve data analytics, thus improving overall fisheries management outcomes. Improved data collection, data analysis, regulation and governance may contribute to sustainable livelihoods and the protection of ocean ecosystems for sustainable fishing (Rose, 2021). The fishing industry's future, thus, depends on well-managed operations that take advantage of the latest technologies available (Hameri & Pálsson, 2003).

2.2 The Role of Data to enhance Supply Chain Management

Data refers to collecting facts and statistics during organisations' operations for further reference or analysis (Majesteye, 2022; Sirianni, 2022). Hoberg (2020), in a research study assessing the generic supply chain concerning current technologies and data, mainly big data, notes that the fundamental role of data capture and capturing systems is to ensure strategic, tactical and operational supply chain management efficiency improvements. The author (ibid) coherently argues that without an efficient data collection system, data-based analytics are hampered, further augmenting (Zhong, Xu & Wang, 2017). Zhong et al. (2017) continue to show that data collection is of paramount importance within any supply chain and more so in fisheries as, without data collection efficiency and effectiveness, it becomes impossible to carry out data-based analytics and therefore develop data-informed decisions. However, as noted by Mills et al. (2011), in their study of small-scale fishers in the fishing industry, systems to provide timely data and allow for control and governance of management policy continue to be lacking. The authors (ibid) state that in the developing world, there is a mismatch between the nature of fisheries and the data systems used to characterise them and these systems are generally under-resourced. Furthermore, these small-scale fisheries are amongst the least monitored fisheries globally, yet e-logistics technologies provide an opportunity for improved data and management for this industry (Rose, 2021).

It, therefore, becomes vital to understand the process of adopting e-logistics technologies. Such technologies are essential given their potential to improve prospects of long-term sustainable fishing by providing timely and accurate data to all fishing stakeholders for data analytics (Westfall, Goldberg, Jud, Thomas, Cusack, Mahoney, McGnigal, Haukebo, Diep & Dwyer, 2020). A need thus is noted not only in the study of data analytics but the adoption of data analytics procedures and the adoption of data analytics enabling technologies that may improve the analytics thereof (Chaudhuri, Dukovska-Popovska, Subramanian, Chan & Bai, 2018) (Chaudhuri, et al., 2018).

2.3 The Role of Data and Data Analytics in the Fishing Industry

71% of the earth's surface is covered by seas and oceans, highlighting the need for fisheries data and data analytics in understanding and maintaining our greatest biodiversity, (European Commission, 2006). Data analytics has been facilitated and improved by the developments in the fourth industrial revolution, enabling the Internet of the Supply Chain, which includes the *Internet of People (IoP)*, *Internet of Things (IoT)*, *Internet of Data (IoD)* and *Internet of Services (IoS)* (Deloitte, 2019). IoP is based on individuals communicating with each other one-on-one and in groups or forums. The shared information can be created, curated and consumed by the people and for the people (Dagstuhl, 2017). IoS refers to a global marketplace for web-based services (Kunz, Fabian, Aleksy, Wauer & Schister, 2012), while IoD refers to an extension of IoT where data is organised in an inter-connected network to infer the needed information for data analysis, creating useful, customised and location-based services, where relevant (Piccialli & Jung, 2018). IoT refers to a network of embedded devices that are uniquely identifiable and these devices have embedded software to communicate between states, e.g. sensors (Rachit & Ragiri, 2021; Tang & Veelenturf, 2019). IoT, IoP, IoD and IoS are all enabled by cloud computing, among other technologies (Vennam, 2020).

Diaz (2020), highlighting the future of the global fisheries industry, concludes his research by showcasing benefits enjoyed by some North American clients. The author (ibid) notes the benefits enjoyed from a business intelligence platform which has enabled further development of specific stakeholders into advanced analytics. The author (ibid) continues to note that the benefits identified, which include the availability of fishing operations data and analyses spanning numerous years, can primarily be attributed to technologies adopted to bring about this change and enable these analyses. This highlights the need to modernise South African fisheries data systems for the needed adaptive and ecosystem-based management in this era of uncertainty, climate change and complex fishery dynamics (Merrifield, et al., 2019).

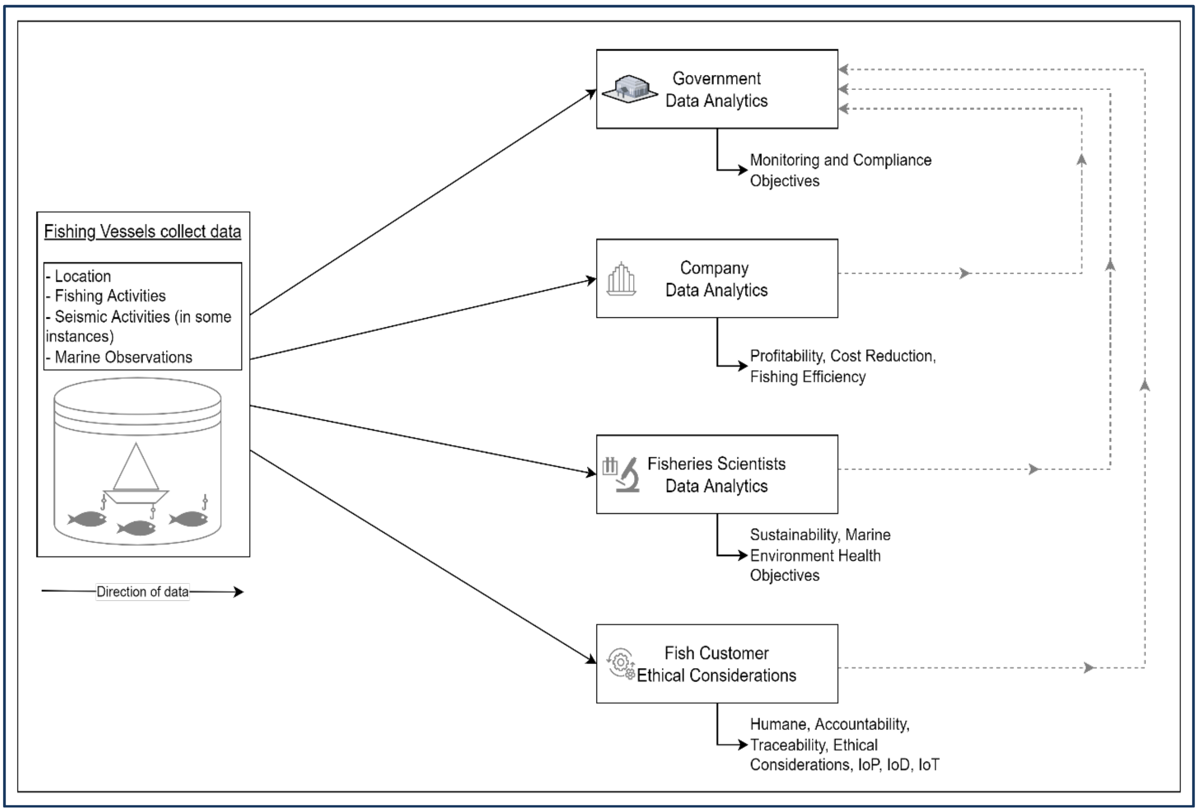


Figure 4: The Role of Data and Data Analytics to different stakeholders

Figure 4 illustrates the relationships between the data source, the fishing vessels at sea, the different fishing stakeholders, and their need for data. While companies need fishing data to improve business operations, governments need the data for natural resources management and regulations development and enforcement. Fisheries scientists, on the other hand, will consider the industry's sustainability, which is necessary to ensure the future success of the fishing industry. The consumer may need data to inform them of the ethical state of their food or employment. E-logistics technologies provide a single version of the truth by enabling a collect-once and store-once data process which in turn provides the same information to all stakeholders.

2.4 e-Logistics Technologies to Facilitate the Application of Data Analytics

Figure 5 displays the data analytics process. E-logistics technologies enable efficient, accurate and timely data management, becoming a significant enabler of efficient and accurate data analytics necessary for a data-informed approach to fisheries management. E-logistics technologies allow for ease of data capture and management at every point of the data management and data analytics point in Figure 5. Using available e-logistics technologies throughout the data journey enhances these data analytics.

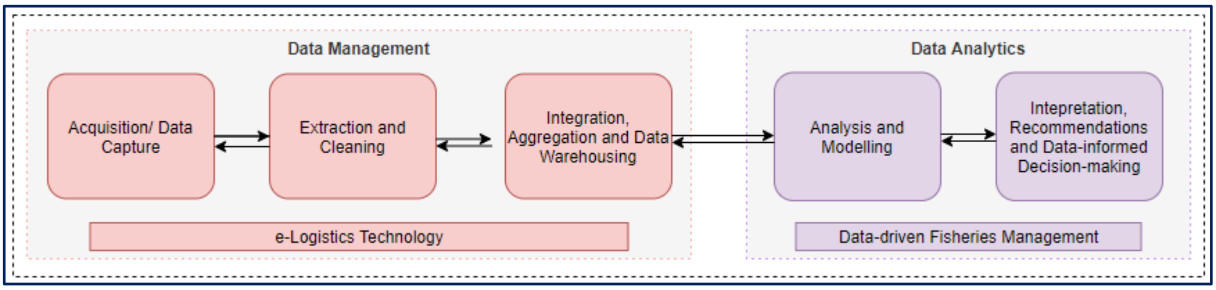


Figure 5: Fisheries Data Management and Data Analytics (adapted from (Cabrera-Sanchez & Villarejo-Ramos, 2019)

Technologies in consideration are the equipment and practices used for finding, harvesting, handling, processing, and distributing aquatic resources and their products (Food and Agriculture Organisation of the United Nations (FAO), 1996). They can improve data accuracy, timeliness, reliability, and storage, further enabling data analytics. Different authors adopt numerous technology classifications in different industries, and these are discussed.

Nwaiwu, Kwarteng, Jibril & Buřita, (2020) note that the emergence of digital technologies, e-logistics technologies digitising processes, has led to a significant transformation of society. The authors (ibid) group these digital technologies into five groups: computing – the cloud; data – big data and analytics; networking – mobile and wireline broadband; people – social media platforms; and things - the Internet of Things (IoT), following Earnshaw's (2017) classification of technologies. In the fishing industry, Merrifield et al. (2019) note that at least three fishing industry-enabling technology advances enable a transition from paper-based systems to digital ones in a cost-effective manner. These include mobile, cloud and mapping on the internet. Bradley et al. (2019) classify enabling technologies as electronic monitoring, reporting, and mobile computing technologies. These are further discussed in sections 2.4.1 to 2.4.4.

2.4.1 Electronic Monitoring Technologies

Electronic Monitoring (EM) research has been on the rise due to possibilities available to substitute or at least support observers in fishing vessels, in order to identify marine protected species that may have been caught during fishing activities and be an audit system for the reported catch in certain instances, including the control of bycatch discards (Girard & Du Payrat, 2017; Mangi, Dolder, Catchpole, Rodmell & De Rozarieux, 2013). EM technologies, as defined by Girard & Du Payrat (2017), include onboard vessel cameras (in certain instances, underwater cameras) and accompanying software, Global Position Systems (GPS) and other location and vessel motion sensors. These include vessel monitoring systems (VMS), referring to a satellite-based system providing vessel data with a time-stamped location, course and speed of the vessel and automatic identification system (AIS), which is a ship-reporting system based on broadcasted messages between vessels with the relevant transponders (Girard & Du Payrat, 2017). The authors (ibid) further note that EM includes a video or photographic system integrated with a sensor, capturing fishing activities and changes within the fishing activities. These have the advantage of providing data relating to catch and discards estimates, at a lower cost to the use of observers. They also enable the automated capture of some fishing activities, allowing the vessel captain or skipper to focus on fishing while the technology takes care of the data. However, this is an emerging technology with isolated trials in different parts of the world with many ethical considerations to assess (Bradley, et al., 2019).

2.4.2 Electronic Reporting Technologies

Electronic reporting relates to the use of electronic logbooks, referred to as e-logs which refer to the digitisation of the paper logbook (Bradley, et al., 2019). Girard & Du Payrat (2017) refer to this as the electronic recording and reporting system (ERS). The latter authors note that using vessel monitoring data together with electronic logbooks (e-logs) with fishing activity data provides a more complete analysis of fishing activities and the impact of these activities within the marine ecosystem. E-logs are essential for fishing activities and catch documentation, thus being a reliable source and store of data for future analytics.

2.4.3 Mobile Computing Applications

Mobile computing applications refer to smartphones and IoT devices using the relevant mobile applications (Bradley, et al., 2019). These may include gear, environment, and other sensors utilised to collect data. These sensors may be used to automate data collection for some fishing activities, thus ensuring the accuracy of the collected data. Bradley et al. (2019) state that mobile technologies, including smartphones and tablet applications, may collect, store, and analyse large quantities of fisheries-dependent data in close to real-time. The authors (ibid) note a benefit of this technology amongst many other benefits; the ability to analyse behaviour in relation to dates and times and overall fishing activities. The authors (ibid) note that mobile technologies may be vital in improving data deficiencies in data-poor fisheries across the globe.

2.4.4 *Other Technologies and Applications*

Other complementary technologies include traceability technologies like blockchain, fish-finding technologies, smart-weighing systems and drones identified by Girard & Du Payrat (2017) and other machine learning tools or capabilities like artificial intelligence and machine learning (Bradley, et al., 2019). Blockchain, sometimes referred to as Distributed Ledger Technology (DLT), refers to the decentralised, distributed ledger for storing time-stamped transactions between multiple computers (Iansiti & Lakhani, 2017). Girard & Du Payrat (2017) note that inherently inhibiting data modification, each block (list of records) contains a hash pointer linking the previous block to the current with a timestamp and other transaction data. The authors (ibid) note that the first implementation in the fishing/ seafood industry was in 2017, providing ample room for adoption. Artificial Intelligence, specifically Machine Learning and Computer Vision applications, are also emerging technologies within fishery data systems (Bradley, et al., 2019). These are enabled as the data capture, storage facilities, technologies and human resources improve.

The identified fishing technologies can potentially improve management and decision-making through context, situation and location awareness (Kamilaris, et al., 2017). They assist with analyses such as catch per unit effort (CPUE) and fish traceability. Thus, environmental transparency and accountability, catch and bycatch analyses, vessel fishing activities and fish processing analyses, location analyses and other fish stocks analyses, including catch predictions and other predictive modelling over time, are all elements of data analytics. In South Africa and, to a great extent globally, managing fisheries, especially commercial fisheries, through continuous stock assessments has become paramount. There is an urgent need for e-logistics technologies' adoption to enhance and complement sustainable fishing efforts by enabling accurate and timely data collection and management and facilitating data analytics processes (Christiani, et al., 2019). OECD (2020) notes this need as an urgent need to invest in monitoring technologies.

Cloud computing is an enabler of all these technologies as it provides affordable, efficient, volume-unlimited data storage (IBM, 2022). Cloud computing refers to the on-demand access via the internet to computing resources (applications and servers), data storage, development tools and networking capabilities hosted by a remote data centre (Vennam, 2020). Mobile technology, remote-sensing data, distributed computing, and storage capabilities are opening new integrations opportunities into agri-food systems, including fisheries, laying down a foundation for a possible agricultural revolution (Gray, et al., 2018).

Bradley et al. (2019) state that fishery information systems that synthesize multiple sources of fishery-related data enable the best data science analyses, revealing where and when to fish to maximise efficiency and minimise risk. Although these benefits of data analytics are known and recorded in different industries, adopting technologies to enable effective and timely data analytics in fisheries has been somewhat slow (Mills, et al., 2011). The future of fisheries in South Africa depends on the development of fishing-enhancing technologies and the adoption of such technologies by supply chain partners (Diaz, 2020; Mazuki et al., 2012).

2.5 Challenges Experienced in Adopting e-Logistics Technologies in the Fishing Industry

Numerous barriers to technology adoption have been researched and identified in various industries, including insufficient monitoring and enforcement drivers leading to illegal fishing activities. Furthermore, high perceived cost, resistance to change, privacy concerns, accountability, infrastructure and lack of governance have been identified as some of the adoption barriers (Rose, 2021). While the data collection systems in the fishing industry, in many instances, remain inefficient, Merrifield et al. (2019) consider the modernisation of the fishing data collection systems as developing, albeit slowly. They note that the fishing industry faces various legal, political, market, funding, and capacity constraints. The authors (ibid) further note that other industries, particularly those in agriculture, like precision agriculture, continue to be transformed by advancements in technology, providing an opportunity for the fishing industry too.

In contrast, fisheries management continues to lag in adopting similarly transforming technologies. Technology adoption, in this instance, relates to the decision to apply the technology and to continue to use it (Ifejika, Ayanda, Nwabeze & Obetta, 2008; Ekong, 2003). It is the process of user awareness, the acquisition and implementation of the technology and finally, the full use of that technology (Kgasago & Jokonya, 2018).

Bradley et al. (2019), in their study identifying opportunities to improve fisheries management through innovative technology and advanced data systems, note that fisheries management is a complex socio-political process that requires access to accurate, consistent and timely data on fishing operations. The authors (ibid) expand on the research by Wilson et al. (2018) on adaptive co-management to achieve climate-ready fisheries and emphasise the need for more precise data collection, reporting, data processing and analysis, including more efficient data transfer mechanisms in close to real-time as possible. They note that data-poor fisheries, which account for over 80% of global stocks, lack adequate data for formal stock assessments, need to expand data collection and analysis, and conclude that fishery data are necessary to support effective fisheries management and encourage fisheries sustainability. They summarise technological innovation and adoption challenges as upfront costs and insufficient capital. Other challenges include legal and bureaucratic barriers, failure to implement data collection standards, lack of trust, and lack of buy-in from fishers, all factors investigated by this research.

A report for McKinsey & Company by Christiani et al. (2019) on precision farming notes numerous benefits of data analytics. They define precision farming as using advanced tools and technologies to optimise operations and management. The report then notes that using these tools enables better decision-making towards profitability and sustainability, may minimise risk and enables better reporting methods to authorities, and therefore better control of the legislated activities. At the same time, the authors (ibid) note that these benefits are enabled by increased data availability, better tools for information transfer, including smartphones and IoT and improved data ingestion from advanced analytical methods like machine learning, artificial intelligence and other facets of the fourth industrial revolution. Decision-making in the fishing industry on fishing operations is complicated and draws from different scientific fields, necessitating tools that consolidate and analyse or provide a window into the needed decision influences. As such, the resultant outcome of the study was the affirmation that there are available technological tools capable of improving fisheries management; e-logistics technologies that can improve the data journey from capture to integration to analysis in the fishing industry. The adoption of technologies over time yielded positive results concerning fisheries management, developed through research and development, and thus continues to play an essential role in the fishing industry (Kumar, Engel & Tucker, 2018; Rauniyar & Goode, 1992).

Girard & Du Payrat (2017), in their study assessing available technologies to improve fisheries discuss the merits of a vessel monitoring system. They note that a complete vessel monitoring system depends on the efficiency and effectiveness of the Fisheries Monitoring Centre (FMC). The authors note that this centre collects various data of various types for different stakeholder engagements and analyses and therefore depends on different pillars, including the use or adoption of efficient data capture systems, databases, application software, Geographic Information System (GIS) mapping and other communication software. The fisheries management problem and, therefore, the solution not only lies in fisheries science but also in the data, the data systems and the adoption and use of these data technologies to improve the fishing supply chain and enhance sustainable fisheries management. As these e-logistics technologies are adopted, there is an increased likelihood of reaping benefits at different points of the supply chain, including improved fishing efficiencies at sea, improved access to markets through the adoption of the world of internet technologies and improved scientific analysis for more robust and dynamic regulation (Bradley, et al., 2019). Furthermore, Girard & Du Payrat (2017) note that there are likely benefits in developing catch traceability and certification programs, reducing the cost of data collection and improving communication and collaboration within the fishing industry.

2.6 Technology Adoption Research Frameworks

2.6.1 Overview of Frameworks to Study Technology Adoption

In understanding human behaviour related to the choice and adoption of technologies, numerous technology adoption studies have been done at the individual and organisational levels in various industries. Theories used in the individual technology adoption studies include the Technology Acceptance Model (TAM) by Davis (1989), the Theory of Planned Behavior (TPB) by Ajzen (1991), the Theory of Reasonable Action (TRA) by Fishbein & Ajzen (1975) and the Unified theory of acceptance and use of technology (UTAUT) by Venkatesh et al. (2003).

The TRA is an intention-based model developed by (Fishbein & Ajzen, 1975). It assumes that the person adopting a technology is under total volitional control (Chang, 1998). It is predicated on the fact that individual behaviour is determined by individual behavioural intention, which informs that behaviour and therefore is the most accurate prediction (Chang, 1998; Fishbein & Ajzen, 1975). An apparent weakness is that, by assuming that the most important determinant of behaviour is behavioural intention, this foundation ignores certain possible influences around organisations' e-logistics technology adoption in the fishing industry as this technology adoption and use may be influenced by factors outside of the individual behavioural intention, including industry competition and government policies. The TPB is an intention-based model that extends the TRA, allowing for situations where individuals may not entirely control their behaviour (Lin, 2007). It considers the influence of attitude, subjective norms and perceived behavioural control beliefs on the intention and actual usage of technology (Lin, 2007; Ajzen, 1991). Lin (2007) states that actual usage is determined by behavioural intention, which is informed by attitude, subjective norms and perceived behavioural control. While it improves on the TRA's identified shortcomings, other frameworks were considered for this research.

The TAM model was initially developed by Davis (1989) and has been modified over time to TAM2 and TAM3 and used in studies complemented by other industry or study-specific factor additions (Cabrera-Sanchez & Villarejo-Ramos, 2019). Lin (2007), elaborating on the voluntary nature of the TRA, states that TAM is based on the theory of reasoned action, which posits that social behaviour is motivated by an individual attitude designed to predict information system use. As individuals recognise that a system or technology will make their tasks easier to perform, complemented by the technology's ease of use, the likelihood of adopting that technology increases (Ajibade, 2018). This assumption cannot be made in organisational research where technology adoption influences are not only personal but sometimes resources or systems related. Therefore, the major limitation is that it is not a practical framework for organisational research and other research where rules and regulations are possible influencers of technology adoption (Ajibade, 2018). Ajibade (2018) further notes that it is also anticipated that organisations' information management attains maturity, and information formality is likely to be promoted. This implies a substantive organisational influence on individual technology adoption and uses decisions.

Furthermore, Chandio, Burfat, Abro & Naqvi (2017) note that the TAM assumptions are insufficient to explain users' adoption and use of new technology, especially in e-government. Related to the fishing industry in South Africa and the Western Cape in particular, many regulations are in place. This research aims to understand the extent to which these government regulations, amongst other identified factors, continue to inform e-logistics technology adoption. As such, behavioural expectations ought to be considered with the levels of compliance Ajibade (2018) and other factors better captured by other frameworks.

Venkatesh, Morris, Davis & Davis (2003) developed the UTAUT model and integrated constructs from TRA, TAM, TPB, ITD (innovation diffusion theory), social cognitive theory and other theories in total eight (Dwivedi, et al., 2019). It was partly developed to counter the weaknesses of the TAM framework (Ajibade, 2018). The model considers performance expectancy as the degree of expected benefits from use. Effort expectancy refers to the ease of using the technology. Social influence refers to how individuals perceive that their sphere of influence (family and friends) think they should use the technology and facilitating conditions relating to the consumer's perception that resources and support will be available to develop a behaviour (Cabrera-Sanchez & Villarejo-Ramos, 2019).

For this study, neither the TRA, TAM, TPB nor the UTAUT were adopted as other technology adoption frameworks capture various fishing industry dynamics more elaborately.

2.6.2 Frameworks used in other Fishing Industry Technology Adoption studies

A study by Mazuki et al. (2012) into technology adoption among fishermen in Malaysia concludes that it is imperative to understand technology adoption in fisheries to encourage fishermen to utilize and adopt technologies in their operations that complement other technology developments in business and industry. They note that some of the influencing factors worth considering include the fishermen's level of education, availability of finance, fishermen's future expectations and predictions and other behavioural and demographic factors. They emphasise the need for organisations to consider possible influencing technology adoption factors by fishermen to enable higher rates of technology adoption in the fishing industry.

In a global study into aquaculture technology adoption, Kumar et al. (2018) found that technical, environmental and socio-political issues related to aquaculture influence technology adoption. However, the authors note that these factors must be considered within their relevant contexts. They further note that uncertainties about technologies exist at the initial stages of technology adoption, yet with time, the adoption process or diffusion improves as technologies are understood. A critical difference between diffusion and adoption is that diffusion refers to spreading innovations among individuals. In contrast, adoption refers to adopting the innovation based on knowledge of the technology/ innovation (Iyabano, 2018).

Obiero, Waidbacher, Nyawanda, Munguti, Manyala & Kaunda-Arara, (2019) identified themes of Farmer/ Farm Characteristics, Technology Characteristics, External Environment, Economic Characteristics and Advisory and Extension Support as part of their research framework into aquaculture technology adoption for smallholder fish farmers in Kenya. The framework is modified from Kumar et al. (2018) and Meijer, Catacutan, Ajayi & Sileshi (2015) and classifies the research themes as; the intrinsic variable, intervening variable and the decision-making process. The authors (ibid) identify education, household size, advisory services and farm-specific characteristics influencing the decision to adopt aquaculture technologies. A key finding substantiated by other technology adoption studies was that perceived usefulness and perceived ease of use indicators are major influencing factors of technology adoption.

A study by Isaac, Comfort, Igbekele & Timothy, (2020) found that profit, education, household size, experience, perceived fish price, cooperative society and perceived cost of equipment were the main factors influencing the adoption of improved fish processing technologies. The study was carried out in Ondo State, Nigeria. It developed this conclusion through a questionnaire where respondents were asked to specify which technologies were used for their fishing activities. The different fishing technologies were classified as traditional methods of processing fish and improved technologies. Survey respondents were categorised into adopters and non-adopters and the conclusions thereof were drawn.

2.6.3 The Diffusion-of-Innovation (DOI) Framework

The Diffusion of Innovation (DOI) Framework has been used in agriculture, medicine, communication and marketing (Chui-Yu, Shi & Chun-Liang, 2017; Greenhalgh, Robert, MacFarlane, Bate, Kyriakidou & Peacock, 2005), e-procurement (Li, 2008) and e-business (Hsu, et al., 2006). The DOI was initially proposed by Rogers (1962) as the process in which innovation, defined as an idea, practice or object perceived to be new, is communicated over time to members within a social system (Chui-Yu et al., 2017; Rogers, 1962). The framework identifies five perceptual characteristics of innovation to help evaluate adoption: *relative advantage*, *compatibility, complexity, trialability* and *observability* (Rogers, 1995). Innovativeness is related to specific independent variables, namely, individual characteristics, internal organisational structural and external characteristics (Oliviera & Martins, 2011).

The DOI framework integrates three major characteristics/ components: adopter characteristics, characteristics of innovation and the innovation-decision process (Taherdoost, 2018) and was developed in considering and synthesising over 508 innovation diffusion studies to explain both the adoption and acceptance of an innovation (Liu, 2019). The framework assumes that individuals have different degrees of willingness to adopt technology and classifies them into five categories of adopters, namely; *innovators*, *early adopters, early majority, late majority* and *laggards* (Rogers, 1995). Liu (2019) notes that *innovators* have the highest financial resources and are generally young, while *early adopters* are those able to adopt an innovation and have a high leadership attitude and comparatively higher financial resources and education with other subsequent stages. The author (ibid) further notes that the *early majority* takes more time than innovators and early adopters to decide to adopt an innovation. In contrast, the *late majority* relates to individuals who are highly cautious and dislike taking risks vis-à-vis adopting an innovation. Lastly, Liu (2019) continues, *laggards* are the conservative group of individuals with the lowest financial resources and are often classified as being traditional in their practices related to innovation adoption. This categorisation applies to organisational technology adoption as well.

Towards a decision to adopt a technology, Rogers (1995) notes that the diffusion process includes communication channels broken down into stages of *knowledge*, *persuasion*, *decisions* and *implementation*. *Knowledge* relates to when an individual is first exposed to innovation but does not necessarily have much information about the innovation. The second stage is *persuasion,* where an individual gains interest in the technology, followed by decisions where individuals consider both advantages and disadvantages of technology adoption and lastly, *implementation and confirmation,* where the individual determines the usefulness of the innovation and completes decision-making to continue to use the innovation (Liu, 2019). Taherdoost (2018) found that the DOI was one of the most common approaches in research relating to Information Management.

2.6.4 The Technology-Organisation-Environment (TOE) Framework

The Technology-Organisation-Environment framework (TOE) brings into perspective the human and non-human actors of a supply chain (Awa, Ukoha & Emecheta, 2016). It categorises influencing factors of technology adoption into the *technological*, *organisational* and *environmental constructs* (Tornatzky & Fleischer, 1990), showcasing the framework's favourable advantage of considering both internal and external factors in determining the adoption of any software or technology. It is an integrative and holistic framework (Ramdani, Chevers & Williams) and is considered a derivative of DOI (Hiran & Henten, 2020). The *technology* construct considers both internal and external characteristics of the technology. At the same time, the *organisation* factors are descriptive, considering the nature, resources and managerial structure of the business and the *environment* construct considers external factors, including regulations or government policies, suppliers and competitors (Hoang, Nguyen and Nguyen, 2021; Liu, 2019; Rahayu & Day, 2015).

Ramdani et al. (2013), in their study of Small-Medium Enterprises' adoption of applications, posit that the TOE model is a robust tool for predicting applications adoption. The framework was used successfully in previous studies assessing the adoption of technologies, including e-commerce (Rowe, Truex & Huynh, 2012), web service (Lippert & Govindarajulu, 2015), and cloud computing (Al Isma'ili and Salim, 2017; Lian, Yen & Wang, 2014). Although initially proving more successful with larger firms, it has been incorporated across different size organizations and provides the most significant insight into inter-organisational information systems (Awa, et al., 2016). The *technological* aspect considers the incremental, synthetic and discontinuous technologies in respective fishing companies, enabling a thorough investigation into e-logistics technologies adoption influencing factors (Baker, 2011).

Hoang et al. (2021) note that the TOE has more explanatory and applied power in research and managerial implication by covering both the micro and macro variables of technology adoption factors. The authors further note that it has been widely used and recognised, as substantiated by Ramdani et al. (2013) and Chui-Yu et al. (2017). However, Chen et al. (2015) and Schüll & Maslan (2018) note that the TOE model assumes that contextual factors directly affect the decision to adopt technological innovation. They argue that the idealization of the decision-making process as entirely rational cannot be accurate in practice. They encourage the use of the TOE model in combination with another framework. Thus the adoption of a combined TOE and DOI framework is further referenced as the TOE-DOI framework and discussed in the next section.

2.6.5 A combination of the Technology-Organisation-Environment and the Diffusion-of-Innovation Frameworks (TOE-DOI): Towards an Integrated Framework for the study

The TOE framework displays its strength in industry and size friendliness as evidenced by numerous information systems research studies carried out (Awa et al. 2016; Yoon & George 2013; Ramdani et al. 2013; Zheng, Yen & Tam, 2011; Henriksen 2006) and is useful in the investigation of a wide range of innovations and contexts. Furthermore, it has been broadly supported in empirical work and remains among the most prominent and widely utilized theories of organizational technology adoption since its development (Awa et al. 2016; Agrawal 2015; Baker 2011). The DOI is broad-based and provides a complementary technology perspective to the TOE by design (Qasem, Asadi, Abdullah, Yah, Atan, Al-Sharefi & Yassin, 2020), thus making the two frameworks good complements of each other. Of note is the composition of the Western Cape fishing industry, which includes both small and large corporations, thus the need for an all-encompassing framework to investigate technology adoption to support data analytics.

Table 2 displays studies that successfully employed a TOE and a complement framework in undertaking research. While the table does not include fishing industry research, the TOE framework, in conjunction with a complementary framework, was applied in answering similar questions to the ones at the core of this research. Industries covered include manufacturing, retail, mobile applications and other generic studies across industries. At the same time, the adoption factors identified by these studies are supported by fishing industry research findings that identified similar TOE and DOI framework variables influencing fishing technology adoption, while using other adoption frameworks.

Table 2: Studies using a TOE framework in combination with a complementary technology adoption theory

Author	**Title**	**Main objective**	**Industry**	**Qualitative/ Quantitative**	**Method**	**Frameworks/ Theories**
Walker & Brown (2019)	Big data analytics adoption: A case study in a large South African telecommunications organisation	Understand factors that influence the BDA adoption process in organisations.	Telecoms	Qualitative	Case study - large telecom organisation	TOE, BDA adoption model
Lai, Sun, Ren (2018)	Understanding the determinants of big data analytics (BDA) adoption in logistics and supply chain management: An empirical investigation	Address the factors determining firms' intention to adopt BDA in their daily operations	Logistics and Supply Management	Quantitative	Survey - 210 organisations	TOE, SC characteristics, DOI
Verma & Bhattacharryya (2017)	Perceived strategic value-based adoption of Big Data Analytics in an emerging economy: A qualitative approach for Indian firms	Provide insight into factors affecting Big Data Analytics (BDA) utilization and adoption in Indian firms	Multiple	Qualitative	Interviews - 22 enterprises, India	TOE
Sabu, Shaijumon & Rajesh, (2017)	Factors influencing the adoption of ICT tools in Kerala marine fisheries sector: an analytic hierarchy process approach	Identifying factors influencing the adoption of ICT tools for a better fish catch, with the help of a multi-criteria Analytic Hierarchy Process decision-making approach	Maritime	Qualitative	Kerala Marine Fisheries Sector	Analysis Hierarchy Process (AHP) and TOPSIS
Nguyễn & Petersen (2017)	Technology Adoption in Norway: Organizational Assimilation of Big Data	Studying factors affecting the adoption of Big Data technology in 3 aggregated stages of assimilation; initiation, adoption-decision, & implementation	Non-specific Med to Large companies	Quantitative	Survey - 336 executives, Norway	TOE, TAM, DOI
Sun, Cigielski, Jia & Hall, (2016)	Understanding the Factors Affecting the Organizational Adoption of Big Data	Applying results of content analysis to develop a framework identifying the main factors affecting organizational adoption of big data.	Non-specific	Qualitative	Literature review to get factors	DOI, institutional theory, TOE
Salleh & Janczewski (2016)	Adoption of Big Data Solutions: A study on its security determinants using Sec-TOE Framework	Research security-related issues pertinent to Big Data Solutions adoption	Non-specific	Quantitative	Survey - 25 respondents	TOE adapted to include Security factors

Author	**Title**	**Main objective**	**Industry**	**Qualitative/ Quantitative**	**Method**	**Frameworks/ Theories**
Ochieng (2015)	The adoption of big data analytics by supermarkets in Kisumu County	Establish the extent of adoption of big data analytics (BDA) in enterprises in Kenya with emphasis on supermarkets in Kisumu County and determine the factors affecting the adoption of BDA in supermarkets in Kenya	5 supermarket chains & 3 independent supermarkets	Quantitative	Survey - 35 people in Kenya	TOE, DOI
Agrawal (2015)	Investigating the Determinants of Big Data Analytics (BDA) Adoption in Asian Emerging Economies	Proposes and investigates the determinants that influence BDA adoption in the context of firms from two big emerging economies of Asia – China and India.		Quantitative	Survey - 106 organisations, China & India	TOE

From **Table 2**, the TOE and complementary frameworks were successfully used as complements in both quantitative and qualitative studies. They were successfully used in different industries and companies of different sizes, further substantiating the relevance and efficacy of using the combined TOE-DOI framework.

Other studies that used a variation of the TOE and DOI combination include a study into determinants of e-business adoption in ERP-enabled and non-ERP-enabled firms (Ilin, Ivetić, Simić, 2017). The authors (ibid) note that the applicability of the TOE and DOI framework in their study in the Western Balkan implies the applicability of this combination of frameworks in developing countries, further substantiating the choice of the framework for this study, in South Africa, in the Western Cape's developing fishing industry.

Wang et al. (2010) studied the adoption of RFID technology in the manufacturing industry using an integrated TOE-DOI framework. They conclude that their study empirically verifies and supports the applicability of the applied framework in understanding business Information Technology adoption.

Figure 6 below summarises the conceptual framework adopted to investigate the adoption of e-logistics technologies within the Western Cape fishing industry. The TOE-DOI complement framework is further explained.

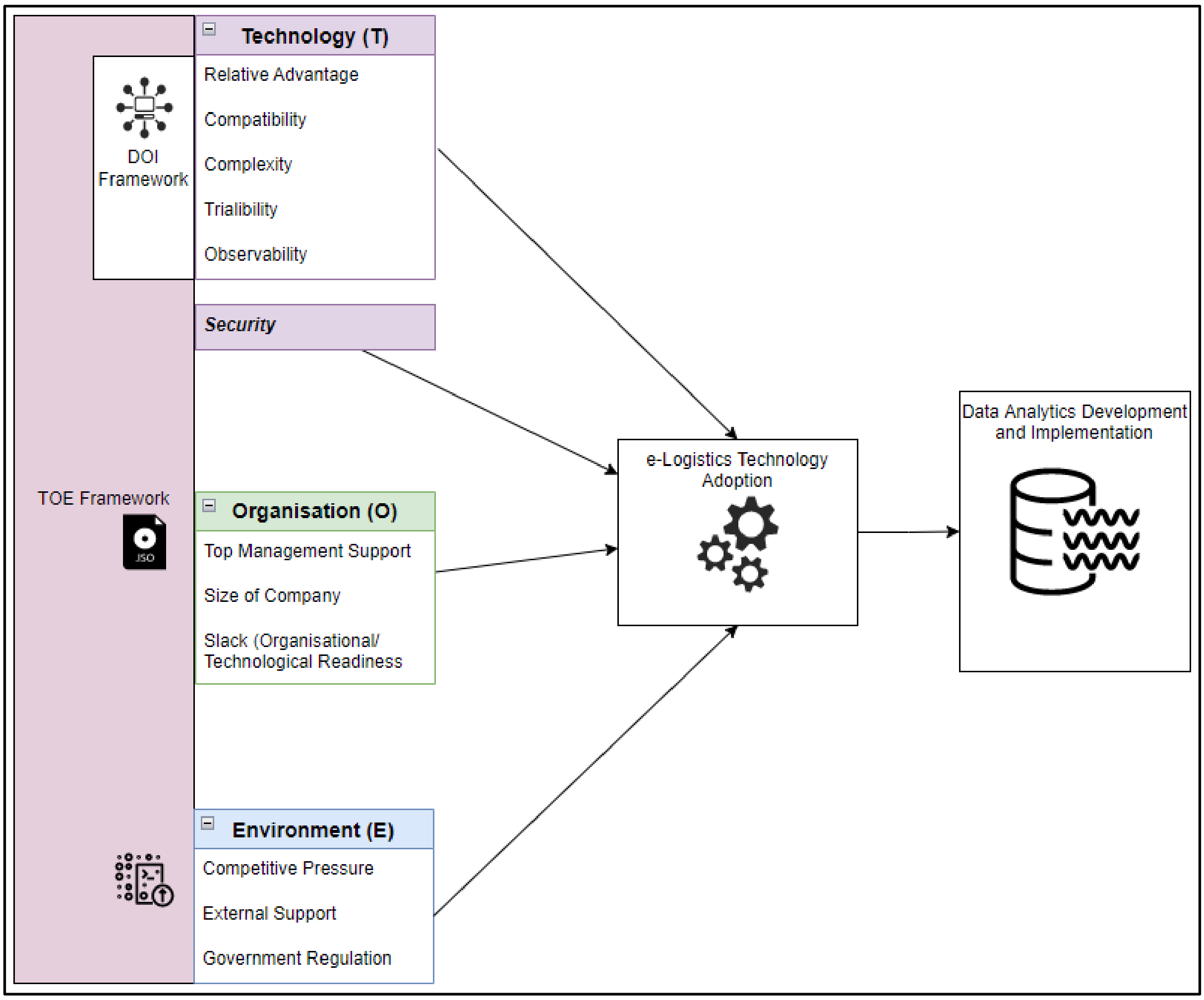


Figure 6: TOE-DOI Integrated Framework to guide project execution

2.6.5.1 Technological Construct

The persuasion stage characteristics of the DOI are incorporated into the *technology construct* of the TOE model: *relative advantage*, *compatibility, complexity, trialability* and *observability*. *Relative advantage* relates to the degree to which an innovation is perceived to be better than the preceding idea (Scott, et al., 2008), usually in terms of what is essential to the user, including economic benefits, social prestige and comfort (Liu, 2019). It may also be considered in terms of productivity, cost-effectiveness or riskiness (Kumar, et al., 2018). An innovation, therefore, is the implementation of new or significantly improved processes or systems or services and, as a scientific field, has been studied in various fields of engineering, science, sociology and economics, amongst many other fields (Bolosha, et al., 2022). When technology is perceived to have a *relative advantage* over a business' current practices, it is more likely to be adopted (Ramdani et al., 2013; Lee et al., 2004). Rogers (1995) defines *compatibility* as the degree to which an innovation is consistent with existing business processes, practices and values. An innovation perceived to be better than the previous is more likely to be adopted and increased *compatibility* increases the likelihood of adoption. Rogers (1995) further notes *complexity* as the degree to which an innovation is difficult to use, *trialability* as the degree to which an innovation can be experimented with and *observability* as the degree to which the results of an innovation are visible to others. The higher the *perceived complexity* of innovation, the lower the adoption rate. The higher the *trialability*, the higher the likelihood of adoption and higher *observability* may translate to higher opportunities for adoption. These five characteristics complement each other and may all significantly influence technology adoption and therefore inform the technology construct research of the fishing industry e-logistics technology adoption.

2.6.5.2 Organisational Construct

The *organisation construct* considers the internal issues within a company (Chui-Yu, et al., 2017). Within the organisation, *top management support,* the *size of the company,* and *slack and absorptive capacity* were considered for the research. *Top Management Support* refers to the degree to which managers comprehend and accept the capabilities of the new technology system (Maroufkhani, Ismail & Ghobakhloo, 2020). Top management may provide a vision, support and commitment to technology adoption (Wang, et al., 2010). The *company's size* relates to the firm's size in terms of employee numbers, revenue and relative size in the Western Cape fishing industry. *Organisation slack (slack)* in terms of organisational and technological readiness relates to the business' (fishing organisation) readiness to invest in new technologies, including technical expertise and Information Technology (IT) capability (Maroufkhani, et al., 2020). This includes the information technology infrastructure and the availability of personnel with the relevant skills. *Absorptive Capacity* relates to the organisation's ability to recognise the value of new information, absorb or assimilate it and apply it towards a commercial end (Cohen & Levinthal, 1990). It considers organisational routines and processes that firms acquire to transform and exploit knowledge producing a dynamic organisation, an attribute imperative for increased new technology adoption and use (Zahra & George, 2002). *Slack* and *absorptive capacity* are investigated in the research as a single concept, considering the various attributes inherent within each concept.

2.6.5.3 Environmental Construct

The *environment construct* investigates the operational facilitators and inhibitors of technology adoption within an organisation (Awa, et al., 2016). This construct considers competitive pressure, external support, and *government regulation*. *Competitive pressure* refers to influences from the external environment, including customers, suppliers and competitors (Maroufkhani et al., 2020; Chen et al., 2015). *External support* refers to the support from vendors or third parties to encourage firms to innovate and adopt an innovation (Maroufkhani, et al., 2020). *Government regulation* refers to rules and policies that either inhibit or encourage the adoption of certain technologies, including technology standards (Tornatzky & Fleischer, 1990).

2.6.5.4 Data Security

For adopting e-logistics technologies to improve data analytics in the Western Cape fishing industry, an additional factor, security, was investigated, mainly *information or data security*. Different literature refers to both concepts in a slightly different manner, with *information security* relating to safeguarding critical information assets from security threats, including data privacy, prevention from corruption, protection from unauthorised access and use, confidentiality and other data risks (AlMindeel & Martins, 2021; Gulappagol & ShivaKumar, 2017). *Data security* in this research is considered within the *information security* definition. *Data security* is based on three fundamental principles: the CIA triad, confidentiality, integrity and availability (Brooks, 2022; Tierney, 2021; Moghaddasi et al., 2016). According to Metric Insights (2022), *data security* covers numerous aspects, including security access, resource optimisation and analytics trust. The author (ibid) continues to note that access control in a governed environment is about achieving a balance between security and discoverability. At the same time, resource optimisation considers the governance of the data and analytics trust relating to measures taken to ensure the data may be trusted and the perception remains as such.

A quantitative study into factors affecting cloud-computing adoption in higher learning institutions found that, among other factors, *data security* was hindering cloud-computing technology adoption (Hiran & Henten, 2020; Hiran, Doshi & Rathi, 2014). This finding is imperative to note and investigate in the fishing industry as e-logistics technologies, to a great extent, are enabled by cloud technologies. This is in line with the recently implemented

Protection of Personal Information (POPIA) Act of 2013 in South Africa. *Data security* was therefore investigated as it relates to intellectual property rights protection, fishing location data, catch-related data and other sensitive fishing operations, including fishers' personal data vis-à-vis the Protection of Personal Information Act (POPIA) and other relevant regulation and internal business operations confidentiality.

2.7 Chapter Summary

In this chapter, an extensive literature review was undertaken to consider the evolution of fishing, the development of supply chains, the definitions of various groups of e-logistics technologies, numerous technology adoption frameworks and the role of data in fisheries data analytics. The chapter furthermore includes a literature review of numerous technology adoption frameworks, their strengths and weaknesses and thus their application to the Western Cape fishing industry. This literature review informed the TOE-DOI adopted conceptual e-logistics technology adoption framework to enable the development of the research instrument, an online rank survey and interviews. The research instrument is further discussed in Chapter 3:.

Chapter 3: Research Methodology

3.1 Introduction

This chapter discusses the methodology used to conduct the research. It highlights the research paradigm, design, population, data collection, analysis and ethical considerations. El-Gohary & Hatem (2009) define the methodology as the theory of methods in which the object of enquiry, fishing organisations and their responses, are made sense of and analysed. Chapter 3: lays out the adopted action plan in carrying out the research and elicits the validity and reliability of the results discussed and the Western Cape fishing industry e-logistics technologies adoption framework.

3.2 Research Paradigm

A research paradigm is a set of assumptions providing a conceptual or philosophical framework for a worldview (Mertens, 2012). It guides the researcher, allows for the development of models and theories, and establishes the criteria for research tools required to realise research objectives (Yong, Husin & Kamarudin, 2021). In other words, the authors (ibid) note that a paradigm provides the principles, procedures and methods to be considered when faced with a similar problem to research. These paradigms include assumptions of ontology, epistemology and methodology (Creswell, 2009). Guba & Lincoln (2005) define ontology as the nature of reality, epistemology as how we know what we know and methodology as the process of the research. According to Healy & Perry (2000), there are four research paradigms, namely; positivism, realism, critical theory and interpretivism.

Positivism is used for quantitative research and revolves around the researcher working with the observable reality that in turn informs generalisations (Yong et al., 2021; Alharahsheh & Pius, 2020). Realism affirms that, while imperfectly understandable, there's a "real" world to discover (Yong, et al., 2021). The authors (ibid) further define critical theory as tending to entail enquiries into long-term historical studies of processes and structures to assess critically, and at times to transform social, political, cultural, economic and ethnic values. Interpretivism, on the other hand, considers the richness of the research context by considering humans as different from physical phenomena, thus a critique of positivism (Yong et al., 2021; Alharahsheh & Pius, 2020).

The interpretivism paradigm was adopted as the research philosophy. Interpretivism relates to the view that reality is subjective and based on individual experiences (Ryan, 2018). This philosophy is also referred to as a qualitative research paradigm (Rahi, 2017). The adoption of this paradigm allows the researcher to 'get into the head of the subjects being studied', as it were, to understand and interpret the contextual reality or thinking of the subject (Guba & Lincoln, 1989; Kivunja & Kuyini, 2017). In this paradigm, a theory is grounded on data generated during the research (Kivunja & Kuyini, 2017). The authors (ibid) continue to note that the interpretivist paradigm exhibits amongst other characteristics, the acceptance that there is inevitable interaction between the researcher and his or her research participants, the realisation that the context is critical for knowledge-building and the belief that contextual factors need to be taken into consideration in any systematic pursuit of knowledge and understanding.

Conclusions drawn from the research were all informed by interactions with fishing industry personnel involved in the day-to-day operations of their fishing organisations. E-logistics technology adoption was considered within the fishing industry's social, political, cultural and economic experiences and reality as shared by the research respondents, in line with an interpretivist paradigm discussed by (Publishing and the Mentoring Network Journal, 2016). Different views of the respondents were analysed and both converging and diverging views were contextually presented to inform the e-logistics technology adoption framework for the Western Cape Fishing Industry. Further application of this research paradigm is discussed in Sections 3.9 and 5.4. The interpretivism paradigm informed the qualitative study design and further guided the contextual analysis of the respondents' feedback. The analysis thus considered the contextual response based on the organisation type, the roles of the respondents, the tenure of the respondents within both their organisations and the industry, and the prevailing social and economic realities in South Africa.

3.3 Research Design

Research design is designing a strategy to carry out a research objective (Babbie, 2010). It entails the development of plans and procedures for research across all decisions from broad assumptions to detailed data collection and analysis (Creswell, 2014). Following Babbie & Mouton (2001), this research was empirical and based on a survey research design. Survey research design is collecting information from a sample of individuals through their responses to questions (Ponto, 2015; Check & Schutt, 2012). A survey design was deemed appropriate in this research since the primary purpose was exploratory and aimed at identifying factors influencing e-logistics technology adoption that can improve data analytics in the Western Cape's fishing industry. Furthermore, exploratory research is ideal when little has been written about a population or topic being researched and when the objective is to listen to research participants or respondents and build an understanding of what is heard (Potter, 2015; Creswell, 2014). This is the case with fisheries e-logistics technology adoption to enhance data analytics in the Western Cape fishing industry.

In general, survey research assumes that every questionnaire item means the same to every respondent. The responses are implied to mean and do the same if they were to be given by a different respondent (Babbie & Mouton, 2001). While the extent to which this is so may not be quantified, in this research, clarity of terms and questions were upheld throughout the online survey and interview development and undertaking. Ambiguities were clarified as respondents requested explanations, while definitions of primary constructs and terms being researched were provided beforehand to prospective interview respondents, allowing for informed responses.

3.4 Unit of Analysis

The unit of analysis relates to what or whom a study is interested in investigating and, therefore, the subject used in the summary description to explain differences (Babbie & Mouton, 2001). Fishing organisations in the Western Cape comprised the unit of analysis for the study. While interviews were held with individuals, the respondents represented organisational values and behaviours that influence the decision to adopt specific e-logistics technologies. Using the organisation as the unit of analysis, the research provides insight into how different fishing organisations adopt e-logistics technologies and inform the industry of possible interventions based on the conclusions drawn from the research. At the same time, considering the organisation as the unit of analysis is an acknowledgement that the organisational decision-making influences the organisation-wide technologies for data analytics.

3.5 Research Instrument Design and Pre-Testing

Prospective interviewees from various organisations were identified within the Western Cape fishing industry directory using online search engines and the Fishing Industry Handbooks, 45th (George Warman Publications, 2017) and 46th (George Warman Publications, 2018) editions. An interview refers to a data collection encounter in which one person asks questions to another person, which may be physical (face-to-face) or through telephone (Babbie & Mouton, 2001). It is a method of collecting survey data (Babbie & Mouton, 2001), allowing for semi-structured in-depth conversations (Mack, Woodsong, MacQueen, Guest & Namey, 2005) to explore respondents' experiences concerning fisheries technology adoption in the Western Cape fishing industry. At the same time, the questionnaire developed to guide the interviews was structured in a manner that minimised non-responses and included complementary prompts where the interviewee needed such encouragement. The questionnaire was developed to encourage the respondents to provide as much information as possible. Each interview was scheduled for forty minutes and took between 18 and 33 minutes to conclude. The interview respondents had an opportunity to complete an online survey, to augment the qualitative feedback received, allowing for the triangulation of the interview outcomes.

Using the TOE-DOI framework, the questionnaire captured the constructs of *technology, organisation* and *environment* influencing factors separately yet, in a coherent and synthesised format. Each of the three concepts included children- classes (areas of study) and within these children-classes, multiple questions were asked to ensure that the respective children-class objectives were realised. The interview questionnaire was spaced out, clearly sectioned and demarcated, and included special instructions, guidelines and prompts to reference during the interview process, as encouraged by Babbie & Mouton (2001). The questionnaire also included contingency questions, where relevant. A contingency question is one where the subject question depends on the response to a preceding question (Babbie & Mouton, 2001). The interview framework is outlined in Appendix B.

At the same time, the online survey included summarised definitions of concepts, constructs and other terms as part of the introduction pack to prospective respondents. This measure was taken to ensure a coherent understanding of concepts by all respondents, further strengthening the research outcomes discussions and ambiguities were minimised.

As part of the questionnaire finalising, pre-testing was done. Pre-testing refers to a stage in research where the questionnaires developed are tested on some members of the study population (Hu, 2014). It is a method of checking that questions work as expected and are understood as intended by those likely to respond to them, as the development of these is an iterative process (Hilton, 2017). The interview questions were mapped against the conceptual framework to ensure that all concepts were sufficiently addressed. They were pretested against research objectives, against the literature and against what other scholars had documented as well.

3.6 Population (Data sources, Sampling strategies and techniques)

Prospective company respondents were selected using purposive sampling. Purposive sampling, a non-probability sampling technique, occurs when one uses their judgement about which sample units are most helpful and representative (Babbie & Mouton, 2001). It is a qualitative research technique used for the identification and selection of individuals and groups most knowledgeable about the study of interest (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood, 2015; Cresswell & Plano, 2011; Patton, 2002). This sampling method supports the qualitative objective of the study, enabling an in-depth analysis of interview responses collected from personnel within the fishing organisations. A total of 90 requests for research participation were sent to prospective organisations in the Western Cape.

In terms of the inclusion criteria, Western Cape fishing operations and fishing technology organisations' personnel most familiar with the industry and/ or their organisation's operations, technology and procurement processes were considered. The personnel considered were in a position to directly influence the e-logistics technology adoption or partook in operations using such technologies.

Once a company was selected through purposive sampling, the next step was selecting respondents for the interview. In noting Tornatzky & Klein's (1982) dilemma of who should discuss technology adoption at the organisation level, multiple roles of respondents were considered. The respondents were drawn from multiple business units and multiple roles. These included technology developers and analysts, senior management, vessel skippers (fishers) and other small-scale fishermen.

The core of the research was to understand factors affecting fishing e-logistics technology adoption in different businesses or organisations within the fishing industry. Therefore, respondents' feedback was treated as organisational feedback within this industry. Respondents were also aware of their assumed capacity in responding to the interview. The engagement was with decision-makers and influencers to understand how they arrived at their fishing technology adoption decisions. There was no sampling stratification for adopters of e-logistics technology and non-adopters. Instead, the line of questioning was tailored depending on whether or not a company had adopted e-logistics technologies and moved towards digital data management systems or still depended on paper monitoring of fishing operations. Formal interview requests were sent in request bundle emails, including the ethical clearance confirmation, data protection affirmation, and anticipated interview date periods. Table 3 summarises the data sources.

Table 3: Summary of the Population

Activity	**Number/ Outcome**
Unit of Analysis	Organisation (fishing organisation)
Number of requests sent	90
Number of consenting respondents	18 (20%)
Number of interviews per organisation	One or two (some organisations had two respondents in the same interview session)
Duration of the interviews	15-35 minutes ➢ The Minimum was 18 minutes long ➢ The Maximum was 33 minutes long
Targeted respondents	Analysts, Senior/ Executive Management, Technology Vendors and Developers, Fishing Associations' personnel, Fishermen and Skippers

3.7 Data Collection Techniques (Research Methods)

Data was collected through interviews on soft platforms and online through an online survey. A request for participation in the research pack was sent via email to prospective organisations. The pack included an introduction to the research, definitions related to the research core areas and my ethics clearance from the university (Appendices C, D and E). Some of the emails were followed up with WhatsApp chats and phone calls as required by the respective organisations' personnel. Where responses were positive, the online survey link was forwarded to the respondents and the interview dates and times were arranged.

The online survey emphasised the relative comparison of constructs within the TOE-DOI framework in order of importance in decisions to adopt an e-logistics technology. These ranks were further qualified during the interviews. The interview process emphasised investigation, depth, and sense-making in relation to factors affecting e-logistics technology adoption to enhance data analytics following a TOE-DOI framework described in chapter 2.6.5. Interview alternatives were offered to respondents for either physical and or soft (zoom/ teams/ or other online platforms) interview sessions due to the prevailing Covid-19 lockdowns. 50% of the interviews were physical, while the rest were online. Key benefits of interview surveys include obtaining detailed feedback (Babbie & Mouton, 2001) and having interviews in a relaxed open environment (Van Esch & Van Esch, 2013). This environment was encouraged throughout the research.

The interview questionnaire and, therefore, the interviews were structured in a manner that allowed the respondents to state the situation, narrate their observations and/or explain the reasons behind the occurring phenomena and their rank in technology adoption. Primary textual data obtained through these verbal interviews were considered for the analysis, complemented by the online survey data. To avoid data loss and ensure the protection of respondents' data and consideration of the Protection of Personal Information Act (POPIA), the collected information was saved onto a central online location (UWC account), only accessible through access to the database administered by the researcher. The interview responses were recorded, where consent was given and stored for further analysis, including coding in Atlas TI and further analyses in Excel spreadsheets and other business intelligence tools like Tableau. All respondents emphasised the need for anonymity in documenting research findings and conclusions. In this light, therefore, the respondents' data security was affirmed before and post the interview sessions and ensured in the documentation of the findings.

3.8 Data Analysis

Data analysis looks for patterns in observations, comparing what is logically expected with what is observed (Babbie, 2010), thus highlighting areas of interest and further study. Both inductive and deductive reasoning, as identified by Leedy & Ormrod (2014), was applied in this qualitative study, identifying patterns within the data (responses given) and letting these inform the prospective model for the adoption of e-logistics technologies for data analytics in the Western Cape fisheries.

Data analysis was undertaken as follows:

a) **Data Validation**: The online survey requested a mandatory rank regarding the importance of the possible technology adoption factors included. The interview questions were open-ended, including contingency questions and prompts where additional insight was solicited to explain the respondents' experiences. A combination of the two research instruments thus was able to more fully capture the primary factors of e-logistics technology adoption in the Western Cape fishing industry.

b) **Data Editing and Masking**: Because of its fixed structure and mandatory completion structure, the online survey required little data processing for analysis. It was collated and presented in visualisations highlighting rank distributions, including the mode. The interviews' data were cleaned, correcting grammar and other coherence-related issues to prepare the data for analysis. This step included masking respondents and organisation names mentioned during the interviews to protect respondents' personal data and organisations' commercial information. At the same time, where consent was provided, interviews were recorded and securely stored. The recorded data were transcribed and documented for analysis.

c) **Data Coding**: As interviews were transcribed, codes of pertinent concepts were developed, refined and applied to the transcripts. Cresswell & Plano (2011) noted that coding is crucial in analysing qualitative data as it captures the subjects discussed and marries these with the research question and objectives. The broad concepts and responses were grouped into codes using Atlas TI. These codes were further developed into code groups that fed back into the TOE-DOI framework, thus enabling the development of some theoretical understanding of primary factors influencing the adoption of e-logistics technology in the Western Cape fishing industry. Coding units were identified and data were classified within these units. A combination of deductive coding based on the framework, supplemented with inductive coding to make provision for that which was not apparent from the framework was used. Deductive coding refers to a top-down approach where codes are developed from an already-developed framework or codebook (Saldana, 2015). Inductive coding refers to a ground-up approach where codes are developed from the data (Saldana, 2015).

d) **Memoing:** This refers to writing notes and memos during the coding process to enhance the analysis (Babbie & Mouton, 2001). Notes were taken down during the interviews and expounded on afterwards, in the shortest time possible between the interview and the expounding of notes. These were used to support interview transcripts at the analysis point.

e) **Concept mapping/ Creating Themes:** A framework showing factors that affect e-logistics fishing technology adoption in the Western Cape was developed following concept mapping. Concept mapping is the arrangement of concepts, showing their relationships and displaying them in a graphical form. Relationships analysis of the data codes was done on Atlas TI, Microsoft Excel and Tableau. These informed the e-logistics technology adoption framework.

Figure 7 below displays the logic applied behind the codes developed. The figure shows an example of a concept, *relative advantage* which is part of the *technology* construct. The development of the codes took place as the interviews were analysed in relation to the research question. Codes with a similar theme were then grouped into code groups. They were assigned to various concepts that were applied to relevant constructs as identified in the TOE-DOI framework and during the research process.

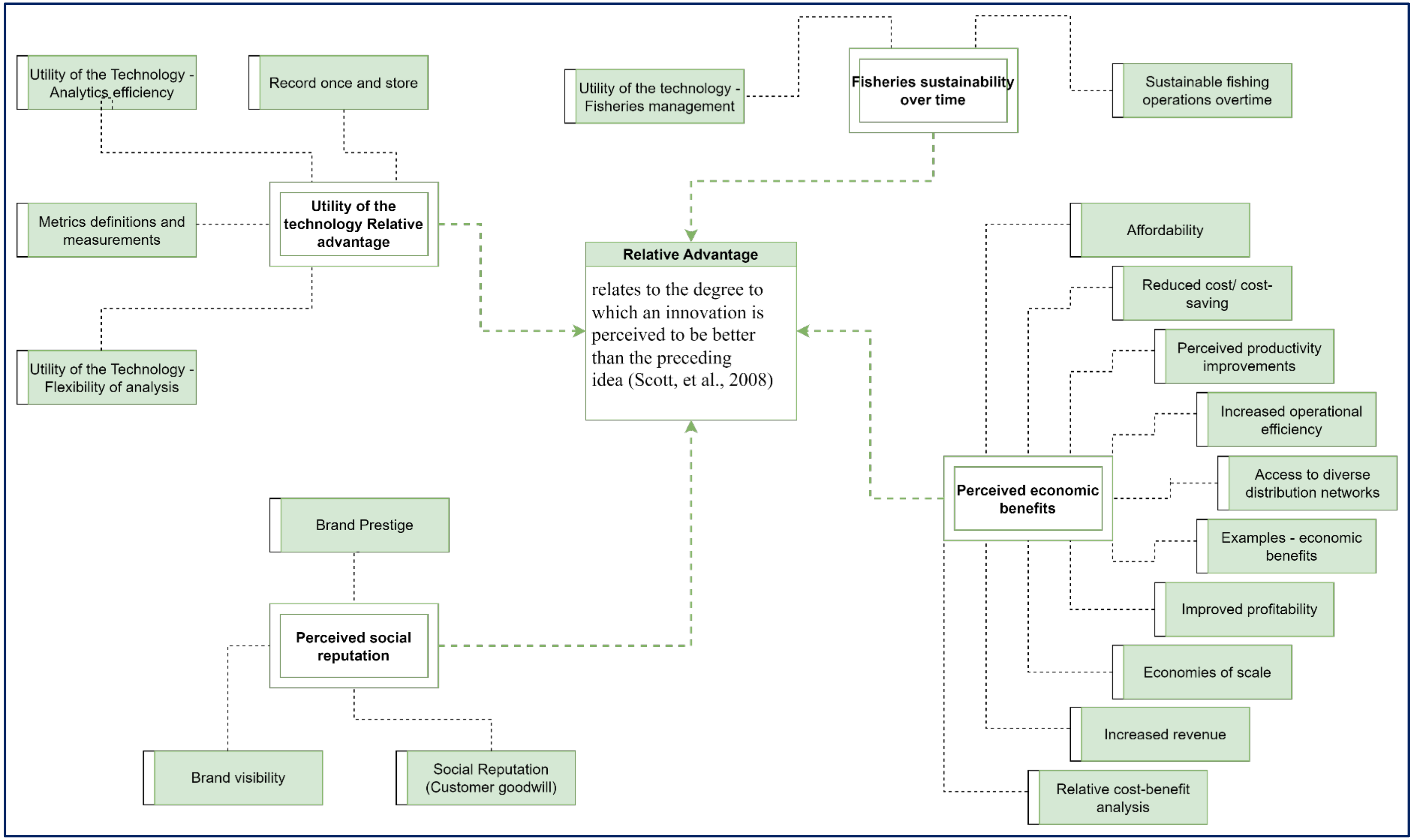


Figure 7: AtlasTI Codes – Analysis coding steps

3.9 Trustworthiness and Authenticity of the Research

Where an interpretivist paradigm is adopted in qualitative research, Guba (1981) suggests four criteria of trustworthiness and authenticity to be considered. These are *credibility, transferability*, *dependability* and *confirmability* of the research. These criteria, the author (ibid) notes, address the concerns of *truth value*, *applicability*, *consistency* and *neutrality* respectively.

Credibility refers to the extent to which both the data and the data analysis are believable, trustworthy or authentic (Guba & Lincoln, 1989). The criterion of credibility relates to how the findings relate to the research reality (Kivunja & Kuyini, 2017; Merriam, 1998). It is often referred to as doing member checks, testing the data with the research participants (Guba, 1981). In this research, the context of the Western Cape fishing industry is presented in Chapters Chapter 1 and Chapter 2 This context is further discussed in the presentation of the unit of analysis (Section 3.4) and the findings in Chapter 4:. The personnel interviewed had a direct or at least a strong indirect influence on the decision to adopt used technologies in their respective organisation.

The criterion of *transferability* refers to the researcher's efforts to ensure that enough contextual data is provided to allow readers to be able to apply the findings to their contexts (Kivunja & Kuyini, 2017). The political, economic, social and technological state of fisheries is discussed to allow the contextual analysis of results. The particular realisation of this criterion is discussed in Section 5.4. Purposive sampling was applied in determining the research population, including the incorporation of interview respondents suggested by interviewed personnel, allowing for a wide range of insight into technology adoption.

Dependability, as defined by Guba (1981), relates to the ability to observe and arrive at a similar outcome if the analysis were to be carried out in the same context. In qualitative research, in particular, this research investigating e-logistics technology adoption factors, where contextual human behaviour is the subject, inferences were made providing the full context of the question and response and therefore, understanding. Verbatim comments were included as part of the analysis both for dependability and confirmability purposes. Guba (1981) notes that inferences and interpretation are as dependable as the researcher possesses the skills and ability to perform a data-informed analysis (Kivunja & Kuyini, 2017). The achievement of this criterion is further discussed in Section 5.4.

The primary goal of *confirmability* is to ensure that biases are minimised or altogether eliminated, and this criterion refers to the extent to which results in the research may be confirmed by other research within the same field (Kivunja & Kuyini, 2017). The authors (ibid) further suggest that the researcher's bias must be reduced by ensuring that findings are driven by research participants and not the preferences of the researcher. In meeting this criterion, the research instrument was set up in a manner that the online survey would complement the interviews thus augmenting findings on either side. Furthermore, the interpretation and conclusions drawn from interviews are augmented by verbatim comments. The realisation of this objective is further discussed in Section 5.4.

3.10 Ethical Considerations

Ethical clearance was provided by the Research Ethics Committee of the University of the Western Cape (UWC). During the research period, complete transparency and open communication channels were ensured with the participating organisations and personnel. Primary ethical considerations included the following:

a) Informed consent was ensured by providing the purpose of my research and how the information gathered would be used.
b) Voluntary participation was encouraged by allowing the interviewed personnel the flexibility to pull out or continue supporting the research throughout the analysis. The respondents had the option to request the withdrawal of their information at any point throughout the research.
c) Confidentiality was maintained by ensuring that interview data served only the purpose intended and were not and will not be shared for any other purpose. Data were also masked to protect the respondents' identities.
d) The anonymity of individuals or individual companies was maintained in documenting research findings and discussions.
e) Interview records were stored according to the University of the Western Cape's storage and deletion policy for research data.

The data collection and storage occurred within secure platforms and only data used for the research were retained. At the same time, data were and will be used solely for the intended research purpose.

3.11 Chapter Summary

Chapter 3 introduces the research paradigm and highlights the research design and methods. The chapter considers the over-arching methodology applied throughout the research, from the problem framing to the research instrument, the ethical considerations and the analysis of the respondents' qualitative data. The chapter rationalises the adopted modus operandi as it relates to the research. A combination TOE-DOI technology adoption framework was adopted for further investigation amongst fishing organisations on the e-logistics technologies adoption factors.

Chapter 4: Research Findings and Discussion

4.1 Introduction

Chapter 4 provides outcomes as they relate to the online survey and the interviews with personnel from the various organisations in the Western Cape fishing industry, according to the research instrument adopted. The online survey rank outcomes, a hierarchy of constructs and concepts of most important to least important, highlighted what respondents acknowledged as being primary e-logistics technology adoption factors. These rankings were subsequently analysed in tandem with the interview responses. The background of all respondents is provided to qualify the responses and analysis discussed in the presentation of the results.

During the analysis, codes were developed and applied. These codes were conceptualised into code groups that were further categorised into elements within the integrated TOE-DOI framework. The codes, ranks and discussion implications are considered throughout this chapter. The chapter concludes by providing insight into some of the nuances further deemed pertinent within the fishing industry but not primarily captured within the TOE-DOI framework. This insight is corroborated by interview quotations and suggestions, informing the Western Cape's fishing industry e-logistics technologies adoption model, further discussed in Chapter 5.3. These findings are furthermore compared to other related research.

As part of the chapter's summary, the most prevalent technology adoption constructs and concepts are discussed as they relate to the type of respondent's organisation. While some constructs and concepts were alluded to across the board, some constructs and concepts featured more in some types of organisations and not others. This discussion forms part of the chapter's summary.

4.2 Background of Respondents

A total of 18 respondents from 14 organisations took part in the research. Of these, 12 were male and six were female. The respondents had varying expertise and experience in their respective organisations and the fishing industry. Half (50%) of the respondents had been part of their organisation for at least ten years before the interview date, while only one person had been in their company for less than a year. The rest of the respondents (eight, 44%) had been with their company for at least one year to at most ten years. Figure 8 shows a summary of the respondents' years of experience within their respective companies.

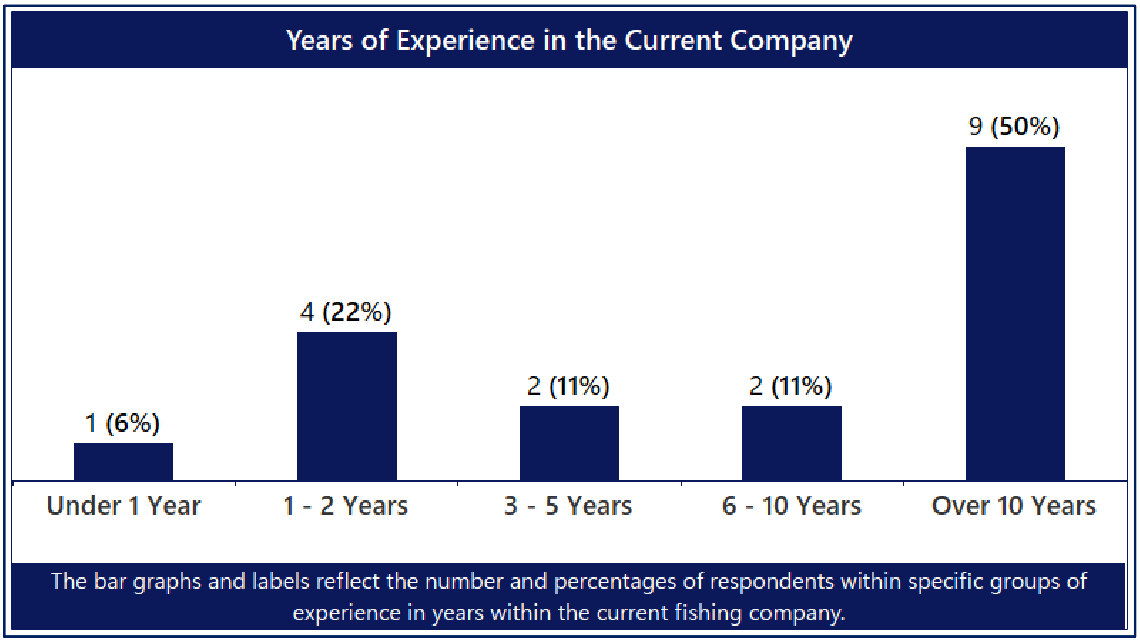


Figure 8: Years of service in the current company

A total of 61% of the respondents, 11, had at least ten years of experience in the fishing industry while 23% (four) had less than five years of experience and 17% (three) had between six years and 10 years of experience. The distribution of experience in the fishing industry is shown in Figure 9.

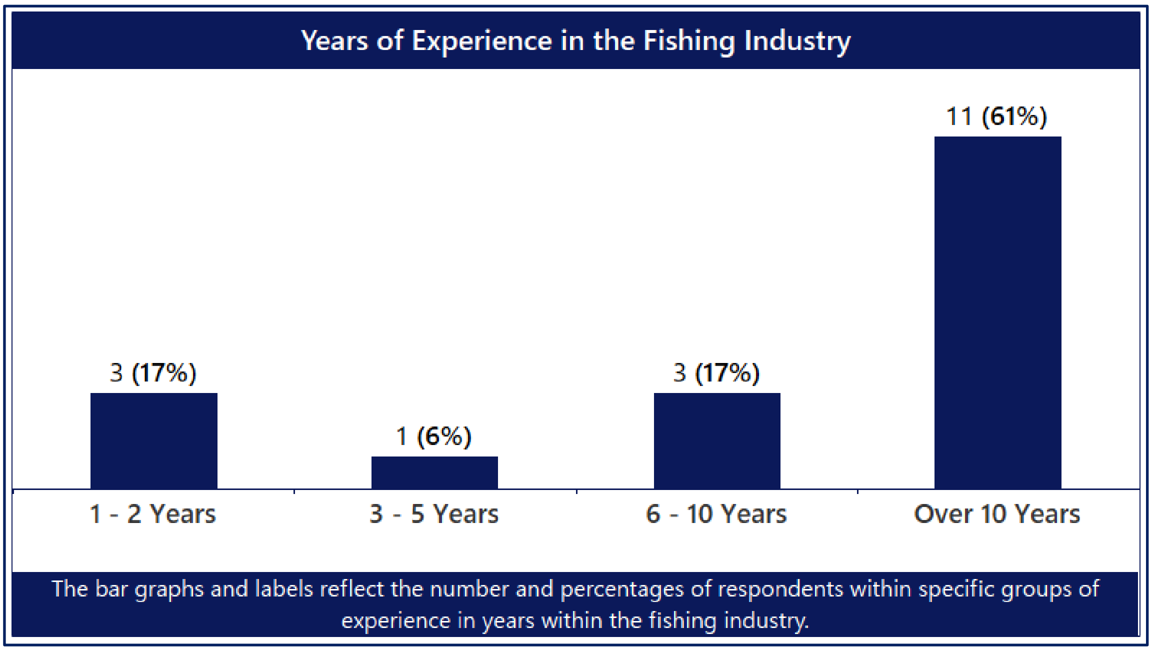


Figure 9: Years of experience in the fishing industry

The respondents had different roles within their companies, from ownership and executive management to analysts and fishers, all involved in procuring and using e-logistics technologies. A breakdown of the respondents by their type of company and their role within their organisation or industry is provided in **Table 4**. The classification of respondents' companies is also provided. The majority of the respondents (38.9%) were from companies that are involved in the management of daily operational commercial fishing activities in the Western Cape fishing industry, followed by fishing technology companies, with 22.2% of the respondents and consultancies and associations with 16.7% and 22.2% of respondents respectively. Within these types of organisations, the respondents occupied varying roles and experiences, an imperative characteristic of the research's objectivity and success.

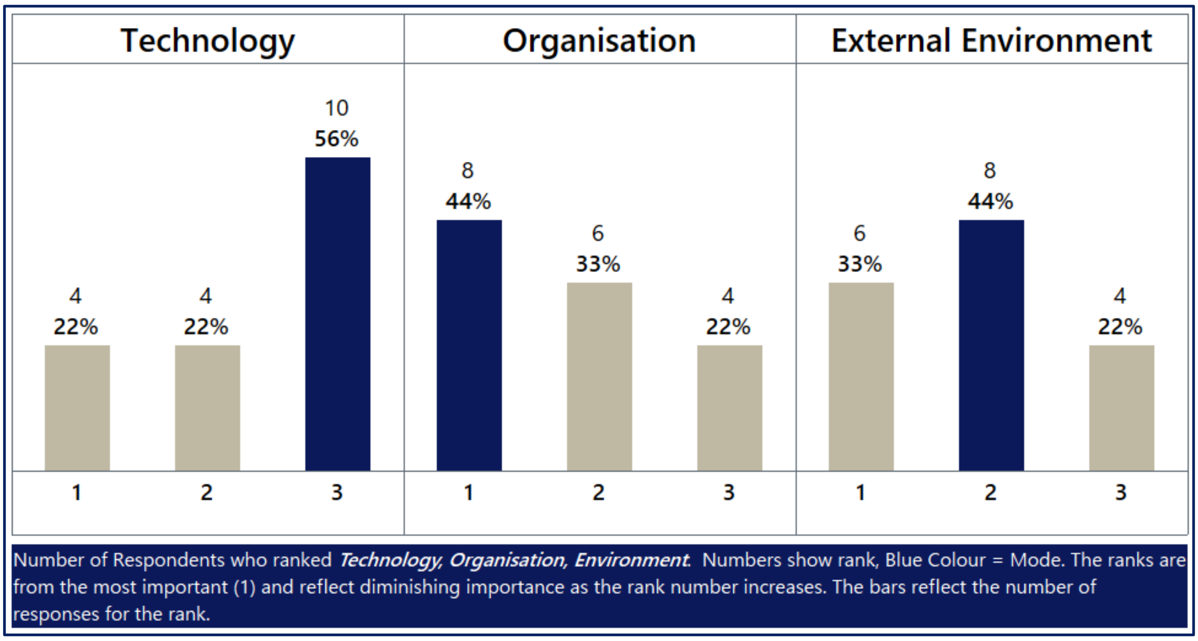
The diverse respondents' backgrounds and the diverse organisations' backgrounds provided objective data that could be analysed towards an e-logistics technology adoption framework for the fishing industry in the Western Cape. Chapter 4.3 further considers the insight obtained and provides in-depth findings and discussions of the prevalent concepts. See **Table 4** below for a breakdown of companies and personnel who partook in the research, whose discussions are analysed and whose responses have been harnessed to inform the Western Cape e-logistics technology adoption framework. Only one person took the online survey but did not have an interview and only one person had an interview but did not have an online survey.

Table 4: Attributes of the personnel and companies that took part in the research

Type of Company	Definition	Type of Role	No. of People	% of People	Online Surveys	Qualitative Interviews
Fishing Association **(4 | 22,2%)**	This refers to an association (group of organisations) of a specific fishery, pursuing a joint purpose.	Executive Management - Operations	2	11,1%	2	2
		Fisheries Management Consultant	2	11,1%	2	2
Fishing Consultancy **(3 | 16,7%)**	A consultancy firm, consulting in environmental sustainability and fishing consulting specialists.	Executive Management - Operations	2	11,1%	2	2
		Fisheries Management Analyst	1	5,6%	1	1
Fishing Operations Company **(7 | 38.9%)**	This is a company that owns/ manages fishing vessels, including managing the operational fishing activities or providing fishing operations services.	Executive Management - Operations	3	16,7%	3	3
		Fisher/ 2nd Mate	1	%	1	1
		Fisher/ Skipper/ Owner	2	11,1%	2	2
		Fisheries Management Consultant	1	5,6%	1	1
Fishing Technology Company **(4 | 22,2%)**	These are the organisations providing and or developing fishing technologies used by fishers.	Business Development Manager - Fisheries	1	5,6%	1	1
		Developer and Analyst	2	11,1%	2	2
		Executive Management - Operations	1	5,6%	1	1
Total Respondents			**18**	**100%**	**18**	**18**

4.3 Online Survey Ranking of TOE elements

The online survey instrument ranked the overarching constructs of t*echnology, organisation* and e*nvironment* against each other. Eight respondents ranked the organisation construct as the most important adoption-influencing factor (44%). Eight respondents (44%) ranked the e*xternal environment construct* as the second most influential technology adoption class of attributes. Ten respondents (56%), the mode, ranked the t*echnology construct* as the least important influencing adoption factor compared to the *organisation* and e*xternal environment*. *Figure 10*: A rank comparison from highest to lowest (1 to 3 respectively) between the three TOE categories shows a summary of these results.



Number of Respondents who ranked ***Technology, Organisation, Environment***. Numbers show rank, Blue Colour = Mode. The ranks are from the most important (1) and reflect diminishing importance as the rank number increases. The bars reflect the number of responses for the rank.

Figure 10: A rank comparison from highest to lowest (1 to 3 respectively) between the three TOE categories

The granular concepts within the TOE-DOI framework were also ranked and analysed. **Table 5** displays the rank outcomes and informs the sections that follow.

Table 5: Table of Ranks of TOE concepts and their percentage distribution

<u>TOE-DOI Constructs</u> | *<u>Concept</u>*		**The rank of the TOE-DOI constructs [1 (most influential) - 6 (least influential)]**					
		1	**2**	**3**	**4**	**5**	**6**
Technology	*Compatibility*	1 | **5.6%**	4 | **22.2%**	3 | **16.7%**	4 | **22.2%**	3 | **16.7%**	3 | **16.7%**
	Complexity	1 | **5.6%**	2 | **11.1%**	1 | **5.6%**	1 | **5.6%**	8 | **44.4%**	5 | **27.8%**
	Observability	2 | **11.1%**	4 | **22.2%**	4 | **22.2%**	5 | **27.8%**	1 | **5.6%**	2 | **11.1%**
	Relative advantage	7 | **38.9%**	5 | **27.8%**	2 | **11.1%**	2 | **11.1%**	1 | **5.6%**	1 | **5.6%**
	Trialability	1 | **5.6%**	3 | **16.7%**	3 | **16.7%**	4 | **22.2%**	3 | **16.7%**	4 | **22.2%**
Organisation	*Human Resources*	3 | **16.7%**	**9 | 50.0%**	4 | **22.2%**	2 | **11.1%**	-	-
	Size of the Organization	-	6 | **33.3%**	3 | **16.7%**	9 | **50.0%**	-	-
	Slack and Absorptive Capacity	4 | **22.2%**	1 | **5.6%**	7 | **38.9%**	6 | **33.3%**	-	-
	Top Management Support	11 | **61.1%**	2 | **11.1%**	4 | **22.2%**	1 | **5.6%**	-	-
Environment	*Competitive Pressure*	6 | **33.3%**	4 | **22.2%**	8 | **44.4%**	-	-	-
	Government Regulation	8 | **44.4%**	4 | **22.2%**	6 | **33.3%**	-	-	-
	Vendor Support	4 | **22.2%**	10 | **55.6%**	4 | **22.2%**	-	-	-

From the results displayed, seven people ranked the concept of *relative advantage* as the most important element within the *technology* construct of the integrated TOE-DOI framework. Five respondents ranked this concept as the second most important adoption factor. Concepts of *observability* and *compatibility* had ten and eight respondents ranking them between first and third most important technology attribute respectively. On the other hand, 13 respondents ranked the concept of *complexity* as the 5th or least important adoption factor within this *technology* construct category, suggesting the least importance for most respondents. *Trialability* was ranked as the fourth, fifth or least influential factor by 11 respondents.

Within the *organisation* attribute, *slack* and *absorptive capacity* were ranked as the most important adoption influencing factors by four people. In contrast, *top management* had 11 respondents recording it as a prime influencing adoption factor. Notably, none of the respondents ranked the *organisation's size* as the most important organization adoption factor, while nine respondents (50%) ranked this concept as the least important adoption influencing factor. The *human resources* concept was ranked by three and nine respondents respectively as the most influential and second most influential adoption factor.

Within the *environment* attribute, the concept of *government regulation* had a modal rank of one (1), with eight respondents (44.4%) identifying this element as the most important factor within the external environment. The concept of *competitive pressure* received the least important adoption factor status from 8 respondents, while six (33.3%) and four (22.2%) respondents ranked it 1st and 2^{nd,} respectively. The concept of v*endor support* had four (22.2%), ten (55.6%) and four (22.2%) of the respondents ranking it as the highest, the second highest and least important adoption factor, respectively. These ranks were further analysed with qualitative interviews, and the findings are discussed in the following sections.

4.4 Technology Construct

Technology, as a TOE construct, although ranked third in terms of comparative importance against the overarching constructs of the *organisation* and the *external environment* by 56% of the respondents, includes concepts that respondents considered pivotal to any e-logistics technology adoption. Therefore, concepts of *relative advantage, compatibility, trialability, observability* and *complexity* are analysed and discussed further within this *technology* construct.

4.4.1 Relative Advantage

66% of the respondents considered *relative advantage* as the first or the second most important technology adoption influencing factor. A further 22% ranked this construct 3rd and 4th, while 11% ranked it either 5th or 6th.

E-logistics technologies need to show their utility by proving to be comparatively better than their preceding technologies. Digitising a process ought to prove that the digital benefits, though accompanied by costs, outweigh the manual and hand-written reporting outcomes. In their ability to improve processes and systems, these technologies must enhance the business' brand visibility and prestige, enabling business profitability and other economic benefits, including a sustainable future for the business and the fishing industry.

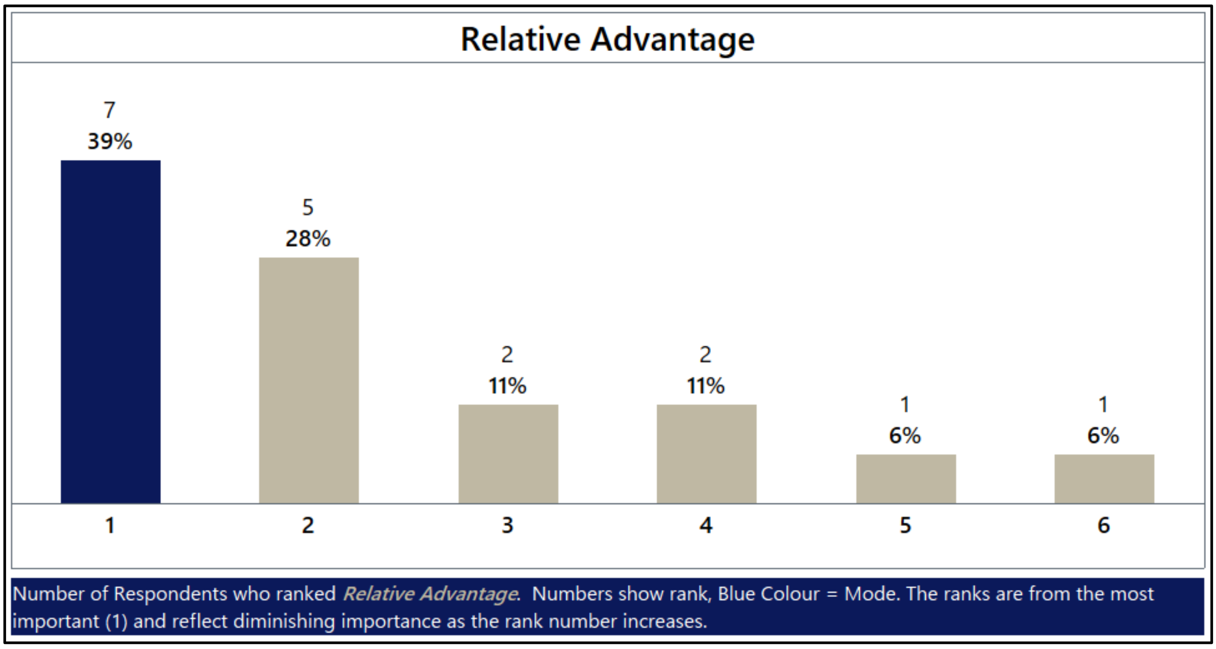


Figure 11: Relative Advantage

The interviews provided further insight into this concept of *relative advantage.* Various codes relating to this concept were derived during analysis. These are explored further in the sub-sections that follow. In particular, the concept of *relative advantage* was de-aggregated into four code groups: the *utility of the technology*, *fisheries sustainability*, *perceived social reputation* and *perceived economic benefits*. These four subgroups were developed and built from multiple codes developed and applied during the analysis. Interview responses informed the codes as they related to the research question and objectives. Table 6 summarises the codes developed and used, the definitions and the number of times the codes were used.

Table 6: Table of Codes – Relative Advantage Concept

Code Group	Code	Definition (comment on the code)	Grounded
Utility of the Technology	Utility of the technology - Analytics efficiency	This relates to how the adopted e-logistics technology allows for more accurate and timely analyses at a minimal time and effort cost to the business.	9
	Record once and store	This relates to the possibility of recording data once for every stakeholder, leading to one version of the truth that can always be referenced and traced back to the creator of the data entry.	4
	Utility of the technology - Flexibility of analysis	This relates to how the adopted e-logistics technology allows for more flexible, accurate and timely analyses as and when needed.	1
	Metrics definitions and measurements	This relates to how users measure the usage and the usage success of the new technology i.e. have these been defined and understood?	1
Fisheries sustainability	Sustainable fishing operations	Because fish are a natural resource, subject to depletion, does the technology enable better operations control and management?	15
	Utility of the technology – Fisheries management	This relates to how technology users understand the technology and how they use it to benefit them, regardless of the purpose of the technology.	5
Perceived social benefit	Social reputation (Customer goodwill)	How the technology may improve or destroy the company's reputation. The technology thus supports the company's reputation of being known as the best.	10
	Brand prestige	The extent to which technology improves the brand's prestige. How the company considers the technology as improving their prestige/ admiration/ respect in the market due to the business success and provision of high-quality products.	2
	Brand visibility	The extent to which the company brand and its products are visible to prospective customers; relates to how identifiable the brand is and whether that identification relates to its success and has been enabled by the adopted technology.	1

Code Group	Code	Definition	Grounded
Perceived economic benefits	Relative cost-benefit analysis	These are the benefits of the utility of technology in comparison to the cost associated with applying the technology to operations.	9
	Increased operational efficiency	How the technology improves the production of fish/ processing time by automating manual work or at least by reducing the need for additional quality checks (e.g. smart weight scales speed up the fish processing process, camera counted fish are less prone to error).	8
	Perceived productivity improvements	The role of technology in improving operations outcomes in terms of productivity.	7
	Affordability	How the cost of the technology may be covered by business revenue and ensure continued and sustained profitability over time.	6
	Increased revenue	How the use of the technology may improve overall business revenue.	6
	Reduced Cost/ Cost Saving	How the use of the technology may reduce costs associated with business operations (e.g. instead of a human observer, use EM).	5
	Improved profitability	How the use of the technology may improve overall business profitability.	4
	Access to diverse distribution networks	This relates to how the technology enables access to markets previously not accessible.	3

4.4.1.1 Utility of the Technology

Analytics efficiency utility, the ability to record data once and store it, the flexibility of analysis and *metrics definitions* were codes developed within the code group – *utility of the technology*. Amongst these codes, *the e-logistics technology's utility in enabling analytics efficiency* featured in more responses vis-à-vis other codes in the same code group. Technology may be among the key differentiators of business success. As such, adopted e-logistics technologies must show higher business value compared to the previously used technologies by reducing the unpredictability of fishing operations. Fishing organisations use mapping services, lure and bait technologies and other fish-finding devices to improve their yield (Jæger & Mishra, 2020). Technology, in this instance, may act as a differentiator between two companies utilising similar processes towards similar outputs. In particular, one respondent, commenting on fish being an unpredictable natural resource, notes the imperative nature of technology by stating:

> *"I think the companies have to compete and the technology gives a certain advantage and outside of being able to report only, but in order to be successful, it's really useful for them, whether it's being able to predict catch or whatever, they have to have it." (Female, Fishing Technology Analyst)*

Furthermore, the respondents identified the need to record and store data and the ability to do this once, efficiently, and with as little effort as possible, both at data entry and data retrieval for analysis. One respondent elaborated further by emphasising the need to be able to access the data as and when needed with ease and stated:

> *"I hate doing things twice and that's what the digital world stops us from doing." (Male, Fishing Operations Executive)*

Related issues of flexible analysis and clearly defined and visible management metrics were drawn out from the interview responses. Adopting e-logistics technologies or "going digital", enables more flexible analyses in a more accurate, coordinated and timely manner. The operations manager continues:

> *"So it's generally bringing on electronic data capturing. It's two sides, one is ahead of the times and ahead in terms of our operations. It is also largely*

driven by ease of access because paper logbooks and storage of information as hard copy is a waste of time because you cannot interrogate it daily, you cannot work with it, you cannot move it around and so from a sound management practice, we have to be in the digital space as much as possible." (Male, Fishing Operations Executive)

The male fishing operations executive noted these issues as part of his explaining why his operations had adopted e-logistics technologies for their daily operations at sea and the analysis occurring onshore. The comments highlight the advantage enjoyed by the fishing companies that can record and store data digitally as analyses become easier, more accurate, timely, and well-coordinated. This, in turn, saves the business time and, therefore, money, implying longer-term and far-reaching benefits from adopting the benefits-enabling e-logistics technologies. All stakeholders in this manner, thus access one version of the truth and the industry may be managed coherently across all stakeholders. Merrifield et al. (2019) found that a major benefit of digitising the supply chain is the ability to record data once, store the data and have a single version of the truth. Additionally, the single version of the truth is derived from a single data warehouse from multiple data sources and was found to be an adoption incentive in a blockchain adoption study by (Jardim, et al., 2021). Technologies that provide this benefit are thus more likely to be adopted than those that omit this benefit. Furthermore, the male fishing operations executive noted:

"My policy was to have data, keep data on our servers and have the flexibility to analyse it whenever we wanted to do so. (Male, Fishing Operations Executive)

The new technology adopted proved its ability to collect and store data to meet the envisaged adopting organisations' objectives. E-logistics that capture data accurately and with less effort, store data and allow for a quick interrogation of the data are thus favoured and more likely to be adopted by fishing organisations. At the same time, those that do not readily display this value are less likely to be adopted.

4.4.1.2 Fisheries Sustainability

The sustainability of the fishing industry in terms of the fish species caught, the sizes, the environmental considerations and the socio-economic realities of South Africa were also highlighted by respondents as influencing technology adoption. The fisheries sustainability code group included codes for *sustainable fishing operations* and *the utility of the technology in enabling fisheries management*. These codes are defined in Table 6. The technologies showing how they consider and alleviate these concepts are more likely to be adopted. One organisation particularly highlighted the socialisation of the industry as a necessary sustainable fishing strategy describing their well-adopted application as follows:

> *"Fishers are joining (us) because this is their exit strategy. Fishers are in a really bad space in South Africa and have been affected by Covid-19, overfishing, climate change, power dynamics, racial issues and many other issues. Joining (us) is a light at the end of the tunnel. Because fishers see this value, they are retained, there's love, there's hope, and that's why they stick to the program. They co-own this." (Male, Fishing Technology Executive)*

As noted by the executive, technologies that enable fishers' interaction and security, including reducing uncertainties related to continued fishing, while averting the currently prevalent trends of overfishing, Covid-19 supply chain disruptions and power dynamics, are gaining momentum in adoption in South Africa. As such, the fishing technology executive notes that fishing technology developers and suppliers must ensure their solutions consider these constructs to increase the likelihood of their technologies being adopted. A female environmental consultant further highlighted the relationship between e-logistics technologies and the increased possibility of reaching sustainable fisheries management by stating:

> *"You own a company, which is giving you a better standing compared to other companies because you have the potential to produce a higher yield of legal, high-value, species, and a low yield of bi-catch, or discarded species. And you're less likely to be impacted by let's say catching too many choked species on the West Coast, right? So that in turn will bring a higher profit, it'll bring a higher turnover and it will also, with technology, bring into play an increased accuracy both in fishing grounds, but also a higher standard of verification of where you are fishing and what you are fishing. That opens you up to international markets." (Female, Environmental Consultancy Analyst)*

Respondents further highlighted that technologies that can show a likelihood of improved catch per unit effort (CPUE) and improved and verifiable fishing data are likely to be adopted as these elements, in turn, imply improved profitability of fishing and continued access to regulated international fish markets. As the respondents noted, there is thus a need to understand the fishing operations and fishing industry, to know the available technologies and to know and understand how these may be used to enhance the data analytics within the business. Building this awareness within organisations improves the adoption of fishing technologies.

This conclusion follows the Andrews (2021) innovation-decision model summary, adapted from Rogers (2003) and Henderson (2005), which emphasises an understanding of needs and knowledge of the technology and pertinent systems as pre-conditions to persuasion and the decision to adopt an e-logistics technology. This understanding has the potential to objectively inform the choice of technology used to solve a problem, in line with the respondents' comments.

4.4.1.3 Perceived Social Benefits

Companies that operate efficiently and responsibly in relation to the environment tend to be favoured by customers. Technologies that elicit this value by providing operational transparency and enabling a positive social reputation are more likely to be adopted than those that disregard this value or do not show this benefit. This logic was elicited by the respondents, with one of them, a female developer and analyst, stating:

> *"I noticed that in some companies, there's a lot of marketing that they tend to do and it's often important what their image is, outside. I think it's important to tell people, as an example, that you're doing things sustainably and to have a good product to back it up and I think for all the companies we dealt with, both locally and international ones, it's been that way." (Female, Fishing Technology Developer and Analyst)*

Codes relating to the construct of *perceived social benefits* included the *company's social reputation, customer goodwill, brand prestige,* and *brand visibility*. Organisations tend to aim continually to improve social perceptions. They do this by providing quality products and services, ensuring that their products and services are fully visible to their market and building a positive image for themselves. Technologies that can show this effort and enable this benefit are thus more likely to be adopted. The female developer and analyst additionally acknowledges this reality and states:

> *"They have campaigns (South African Fishing Companies). If you look at their packaging, there are certain certifications and certain quality markers that are important to them. And they are proud of this and they are also proud to put it on their packaging. I also know of one international company that takes pride in talking about the fact that they are tracking their fish from production to the table. It's something that's costing them money to implement and to do but at the same time it's giving them a lot of clout." (Female, Fishing Technology Developer and Analyst)*

The observations, therefore, suggest that e-logistics technologies that enable businesses to develop a positive brand image by addressing the business customers' areas of importance are more likely to be adopted. As the business develops a positive social reputation, its brand becomes more visible in the industry and more recognisable to the consumer. This, in turn, implies developed brand prestige through the advantage that the unique technology has provided the business, further enabling economic benefits. These economic benefits include economies of scale achieved through mass standardised and automated production, reduced cost per unit of producing fish, increased revenue and other financial incentives. The fishing technology organisation developer and analyst further elicited blockchain, amongst other technologies, as use cases in other industries towards similar objectives.

It is also imperative to realise that this element relates to perceptions. The onus, therefore, tends to lie with the developers and vendors of the e-logistics technology to show and prove the value of their technologies and encourage a positive image of the e-logistics technology on offer to the business seeking this value before adoption. On the other hand, the fishing organisation ought to learn how to identify areas of improvement within their operations, navigate the technology options and selected technology, and further draw the full benefits of using this newly adopted e-logistics technology.

4.4.1.4 Perceived Economic Benefits

Collecting, storing and analysing data is not necessarily the end objective. Instead, companies are interested in creating business value and thus an interest in technologies that display this value (Hartmann, et al., 2016). Technologies that can show likely economic benefits if an investment is made are more likely to be adopted. As Naude & Badenhorst-Weiss (2011) stated that businesses ought to decrease costs and increase profitability to remain competitive, the *perceived economic benefits* construct was alluded to in multiple conversations. A fishing technology developer captured this by stating:

> *"They would want to receive economic advantage and prestige within the industry. I think it is a driving factor. I think people who drive the implementation of these technologies are people who believe they would get value. If they didn't believe they would get value, they wouldn't invest." (Female, Fishing Technology Company Developer)*

Under the *perceived economic benefits* code group, codes were developed and these primarily included financial codes of the *relative cost-benefit*, *cost-saving*, *affordability*, *increased revenue* and *increased profitability*. Furthermore, efficiency codes were developed, including *increased operational efficiency*, *perceived productivity improvements,* and *access to diverse distribution networks*. The respondents could show that technologies that provided these benefits were already adopted in their organisations or would be more likely to be adopted.

One of the respondents provided a unique example, describing an occurrence outside of the South African fishing industry. The example showcases the power of the Internet of People, particularly social media and the financial impact of the socialising of fishing activities. The executive notes:

> *"There's a fisherman down in New Zealand. He live-streams his fishing; literally, you can log into a website and see his vessel 24/7 even when he's fishing. He, actually, has gotten more price per pound. He's gotten three to four times, the price per pound when he sells his fish versus the other fishermen in his port." (Male, Fishing Association Executive)*

The positive portrayal of electronic monitoring and other onboard interactions between people, fish and technology in terms of transparency and increased revenue has encouraged more small-scale fishers to adopt similar strategies for their business, the male executive notes. As value is shown in these operations, adopting similar technologies as used in the example given is more likely. It must be noted, however, that some data, especially location data, is sensitive for fishers, especially larger-scale fishers, suggesting that a balance between transparency, economics and privacy is necessary. This is further discussed in Section 4.7.

Closely tied to perceived financial benefits are perceived productivity improvements. Technologies that allow fishermen to catch more fish with less effort are more likely to be adopted. The fishing process at sea to landing catch at the harbour is complicated. It may include multiple stakeholders and may last for days, weeks and or months in a bid to meet all compliance and ethical rules. A fishing consultant, consulting within various organisations and fishing associations with 6 – 10 years of experience stated:

> *"I just know that they (various fishing companies) have to produce thousands of tons of fish every year and to keep track and check all that they are producing. Companies produce probably something like 200 different products. Some of them, are for local consumption, and some of them are for overseas. Because you're dealing with different cuts of fish, you're dealing with different species, various processed products, it is very, very complicated and you need to keep track of it all. So they have electronic and logistics systems to do that." (Male, Fishing Consultancy Executive)*

This comment was made during a discussion of how e-logistics technologies enable easier data analysis. Therefore, a company that strives for productivity improvements would consider technologies that enhance this analysis. In the fishing industry, processed fish products may need to be reported to fisheries scientists and the government, thus adopting technologies that do the complicated fisheries management while allowing the fishers to do what they do best; fishing. During the interviews, many fishers made clear distinctions between increasing revenue and profitability by emphasising that efficiency-building (or cost-reduction) was able to increase profitability, even before increasing revenue, thus the need for technologies that provide efficiency possibilities towards these goals.

A female analyst concluded her remarks by stating:

"100% (replying to the importance of relative advantage), look, someone will only be convinced to use a system if they can understand it and they can understand how it will benefit them." (Female, Fishing Consultancy Analyst)

In adopting e-logistics technologies that improve internal business operations, therefore, there is an understanding element necessary. There is a need to understand data analytics and e-logistics technologies and how these may improve the present status quo. In technology adoption, there's the knowledge of the technology and the benefits associated with the technology on the one end, and the knowledge of operations on the other. This realisation was substantiated by multiple respondents and is further discussed in the following sections.

This finding is consistent with similar technology adoption research in other industries. Different studies found that perceived usefulness increased trust in m-commerce and, therefore, the likelihood of adopting m-commerce (Thevaranjan & Samantha, 2022). A study into factors affecting the adoption of augmented reality in e-commerce found relative advantage as an important variable in influencing adoption (Chandra & Kumar, 2018).

4.4.2 Compatibility

A total of 5.6% of respondents ranked *compatibility* as the most important adoption-influencing factor, while 22.2% ranked it as either second or fourth in terms of importance. Figure 12 shows a summary of the respondents' rank of importance of the concept of *compatibility* concerning other technology factors identified in the TOE-DOI framework.

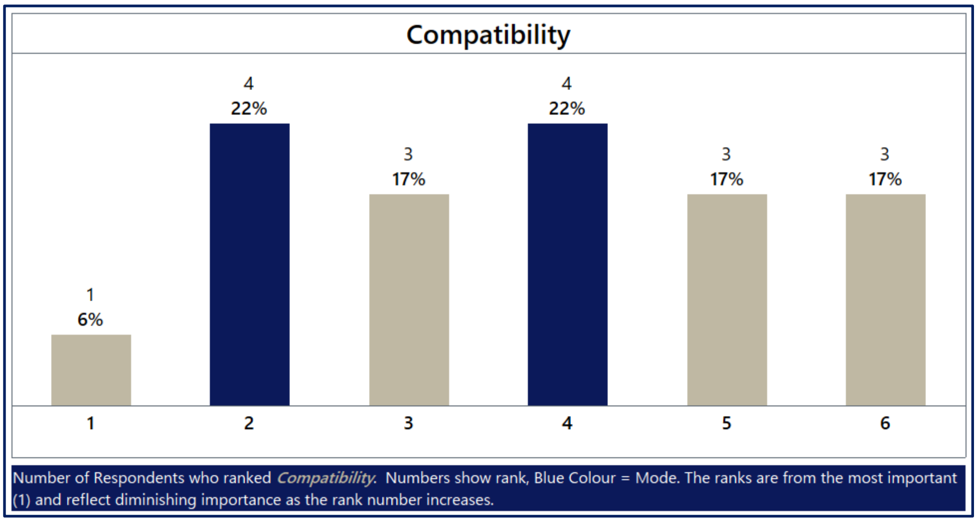


Figure 12: Rank of Compatibility as a primary technology adoption factor

Compatibility was analysed in terms of the compatibility between already existing technologies and the new e-logistics technology, referred to as *systems compatibility*, and the operational status quo processes and the new technology with its implications for operational processes referred to as *process compatibility*. Codes were developed and applied as summarised in Table 7.

Table 7: Table of Codes - Compatibility Concept

Code Group	Code	Definition	Grounded
Technology, Operations and Regulations Compatibility	Utility of the technology - Seamless fit into systems	This relates to how technology can be easily adapted and applied to fit into the business.	5
	Assessment of technology's compatibility with industry-standard operating procedures	How trialling software enables the assessment of operations against technology usage before full adoption of technology.	4
	Business propensity to change	Businesses are sometimes rigid and the more flexible they are, therefore, the more likely they are to adopt newer technologies and newer ways of working.	2
Fishing Operations Logistics	Utility of the technology - Operational logistics	How the use and relevance of the technology improve operations. This includes how technology users understand the technology and how it may be used to benefit them (e.g. knowledge of data analytics).	4
	Space logistics in the fishing vessel	The reality of limited space and limited ability to implement certain technologies (e.g. some technologies only work in certain gadgets, yet certain hardware requires space and cabling).	4
	Rough seas and prevailing sea weather conditions	The role of "at sea" environment and types of hardware possible to incorporate technologies in. This includes colour screens and touch-screen versus typing possibilities.	3

4.4.2.1 Technology, Operations and Regulations Compatibility

How compatible an e-logistics technology is with already existing systems (systems compatibility) did not feature in the interview discussions as a primary factor influencing the adoption of the prospective technology. Systems compatibility, while ideal, did not stop fishermen or fishing companies from exploring new technologies, including those not compatible with their existing technologies. On the contrary, technology would sometimes drive the processes of how things ought to be done, including the transformation of internal processes and systems. A male fisheries consultant stated:

> *"I don't think the adoption of the technology is limited by any mismatch or any incompatibility between the fishermen and what they are already using*

and like kind of how they use that information as they run their business. It is a small factor but it's not as important as some of the other things that I've mentioned." (Male, Fisheries consultant, Fishing Association)

Codes identified to inform this code group were *Utility of the technology - Seamless fit into systems*, *Assessment of technology's compatibility with industry-standard operating procedures* and *Business propensity to change.* While the discussions featured these components, respondents did not associate these elements as primarily driving the e-logistics technology adoption realities in the fishing industry. Furthermore, a male executive who oversaw the digitisation of his business' operations notes:

"You need something fit-for-purpose for your business. It's not a one-size-fits-all. People who get into operations tweak the operations. (Male, Fishing Operations Executive)

It is imperative to note, therefore, that while compatibility with existing systems did not feature as a primary driver of adoption, the respondents appreciated the ease of adoption when an e-logistics technology is compatible with existing systems. However, this incompatibility was sometimes associated with a need to optimise operations as opposed to a barrier to adoption. A fishing developer and analyst noted:

"I think companies have certain systems set up and we don't necessarily integrate well with other systems (speaking of their fishing technologies suite). There have been isolated requirements that needed integration but that has not stopped us from solutions development. It has not been a priority for us to integrate with many other systems. It has not been a priority and so those kinds of things have not been a primary focus." (Female, Fishing Technology Developer and Analyst)

Respondents continued to identify other elements of the *technology* construct as more urgent and pertinent to meet in technology adoption outside of *systems compatibility*. *Process compatibility*, a compatibility concept, is further discussed.

4.4.2.2 Fishing Operations Logistics (Process Compatibility)

Compatibility was further explored in terms of *process compatibility* and this relates to how fishing occurs and how e-logistics technologies capture the process, record the data and store it for further analysis.

Fishermen, in their endeavours, emphasise safety, profitability, productivity and efficiency outcomes. Technologies used must complement this objective and not compromise it. As such, compatibility between the fishing processes and the e-logistics technologies was an important factor in adopting e-logistics technologies. An executive who also specialised in fishing vessels engineering stated:

> *"The fishing environment is very harsh. The weather elements sometimes determine what technology may be out at sea and what technologies may not be out. Rugged laptops are a better alternative to any other laptop, while smaller computers are ideal due to space logistics within the vessels. Cameras can only be mounted at certain areas of the vessel on certain size vessels. These factors, therefore, influence the technology to be adopted and used and how that technology develops. As a rule, fishermen must focus on fishing and not any other role. Technology must therefore complement the fishers' efficiency." (Male, Fishing Operations and Engineering Executive)*

The fishing environment logistics were further discussed by another executive who stated:

> *"I mean, at the end of the day in fishing, it's about getting the fish. In your supply chain and value chain, that's what it's all about. Primarily though, technology must enhance your supply. (Male, Fishing Operations Executive)*

Compatibility was considered a logistical necessity as it relates to how e-logistics technology fits into business operations. This concurs with Fujita et al. (2018) conclusion that because many small-scale fisheries employ open-deck vessels, there are few places to place electronic devices onboard safely. The author (ibid) continues to note that many vessels tend to have limited electricity and internet and cellular coverage onboard. As such, this reality may inhibit the adoption of some technologies while encouraging the adoption of other technologies.

Technology developers and providers should consider the realities of fishing processes and the fishing environment, developing and providing fit-for-purpose solutions with minimal disturbances to the fishing experience. The compatibility element additionally considered the user interface of various fishing software solutions like electronic logbooks. This includes the colour screens and the at-sea usability, which were identified as primary adoption factors. Further elements of ease of use were considered within the complexity concept.

4.4.3 Complexity

The complexity concept considered the perceived ease of use, especially related to software navigation. The concept was ranked fifth by 8 (44.4%) of the respondents, while 5 (27.8%) considered this factor the least important. Interview discussions further substantiated this outcome in that the respondents appreciated that any new technology might be complex at first sight until the users who adopt it, understand it. To further qualify this perspective, a few respondents appreciated the vendor availability and technology development within the South African fishing context, stating that their technologies were already being developed with the fishers and fishing operations in mind, thus being considered user-friendly. *Complexity,* thus, has not played a primary adoption influencing role. The figure below shows the complexity rank concerning other technology factors as ranked by the research respondents.

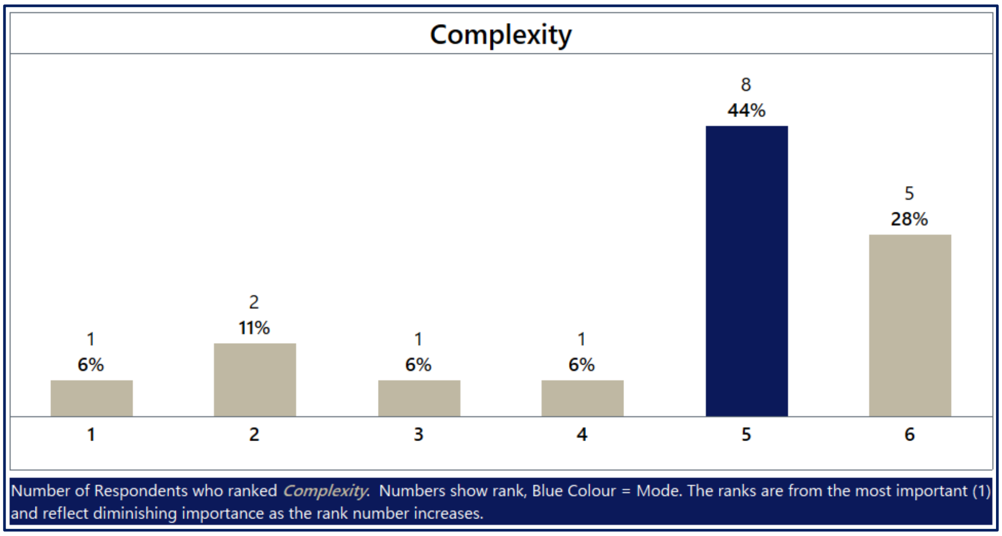


Figure 13: Rank of Complexity as a primary technology adoption factor

Furthermore, within the *complexity concept* context, the *utility of the technology* as it relates to people and the software was considered. The codes in **Table 8** were developed and applied to analyse how people and new technologies interacted.

Table 8: Table of Codes – Complexity Concept

Code	Definition	Grounded
Perceived simplicity (and complexity) of the software by users	How technology users perceive the technology to be simple to learn and use.	6
Knowledge-sharing	Technology that shares information and shows value in enabling the fishing experience is more likely to be adopted.	1
User interface and experience (UI & UX)	How intuitive the technology is vis-à-vis the fisherman's experience and skills. A fishing activity follows standardised steps and therefore, the available technology is considered in relation to the operations process.	1

A fishing technology developer and analyst stated that complexity in her experience has only been an issue for continued use of the technology instead of initial adoption. She notes:

"I think it (complexity) is weighed together with why they want the software. If there's a need to comply then they will take whatever is available and then the cost will be a bigger consideration and again they will go into it assuming the software is not difficult to use. However, we've noticed that once the software is out there the issues that come back are usually related to usability. So if we want to retain clients it is to be easy to use. (Female, Fishing Technology Developer and Analyst)

A major aspect highlighted was that it is impossible to exhaust the usability of any technology at the trial or show-and-tell level. Yet, continued use of the technology provides a more objective complexity or ease of use assessment. She also highlighted the need to assess the complexity concerning the purpose of the software. For example, regardless of how complex a technology is, if it is mandated by the government or fishing authority, complexity would not matter and the fishing companies would instead adopt the technology.

The findings in this research related to complexity are similar to those of Thevaranjan & Samantha (2022), who, in their study of factors influencing m-commerce adoption, found that when a technology is considered useful, there may be a drive to consider complexity as a secondary factor instead. The respondents emphasised the usefulness of e-logistics technologies and the associated efficiency and productivity benefits preceding the complexity consideration.

4.4.4 *Trialability*

Trialability was ranked by 4 (22.2%) respondents as the least important adoption influencing factor and by another 4, the mode, as the fourth most important factor. Only one respondent ranked trialability as the most critical factor influencing the decision to adopt an e-logistics technology.

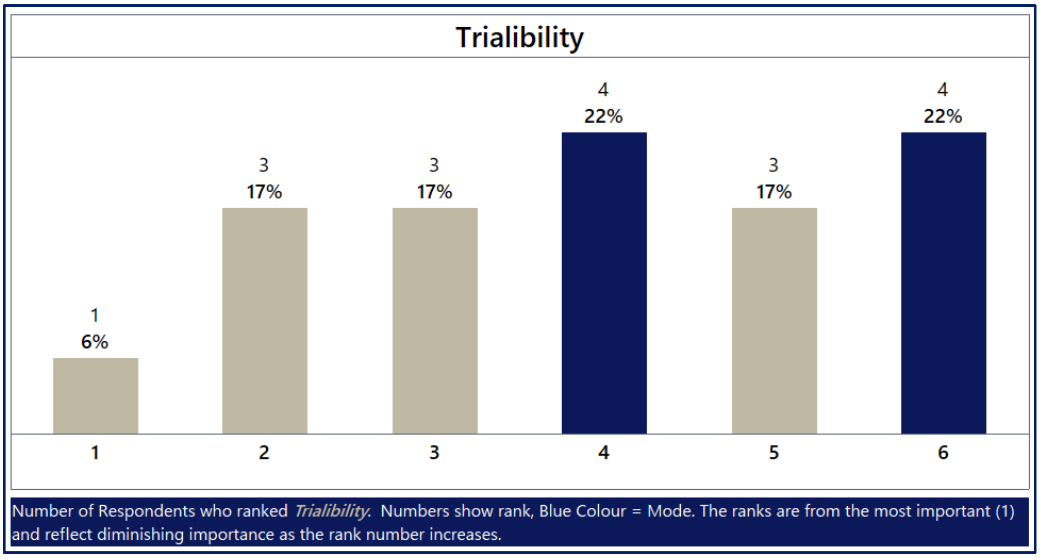


Figure 14: Rank of Trialability as a primary technology adoption factor

One of the pertinent considerations within this category is the trial purpose. It could be related to the accuracy, increased profitability, compliance or other data analytics. Peter Drucker stated that if you cannot measure it, you cannot manage it (Havard Business Review, 2010). Therefore, trialling a technology requires an understanding of the trialling purpose and expected outcome or result to measure technology performance against. One respondent stated:

> *"I think it's important for management or ownership to see what the difference is between the traditional methods and the new methods, right? So they can gauge. Okay, how long did it take me? But also, you know, how many errors did I make? What were my differences in total? How many times did I get stuck? It's also important for log books. How often did the system have to restart? What were the problems with the system itself? And usually within trialling a system as well." (Female, Fishing Consultancy Analyst)*

However, the respondents did not consider the ability to trial as an essential factor, but rather, stakeholder partnerships as the important factor. As such, the fishing operations organisations were not keenly interested in being provided with a complete technology product to trial but preferred partnerships during the development of e-logistics technologies and the adoption and use of the technologies thereof. A fishing executive stated:

> *"Don't exclude people in developing technologies. Always pass the knowledge that you have. People do what they do and technology complements what people do." (Male, Fishing Operations Executive)*

One of the female fishing technology developers further noted that trials are a good measure to pilot new technologies. However, fishing companies had continued with technologies whose trials would have been considered failed, thus implying that other more important factors are at play. She concludes:

> *"But piloting has been one of our main means of getting people to buy into this software, but not piloting on its own, but responding to feedback from the client during a pilot. This is because we've never gotten it the first time, I mean it is after years of building the software that we've almost been able to create a predominantly ready, plug-and-play solution. But a trial has been important and has given us a lot of success in combination with customer support. I must say that some pilots have not gone well but the clients still bought into the solution meaning there are other factors to consider outside of the trialling." (Female, Fishing Technology Developer and Analyst)*

While trialling a solution is necessary, other factors driving technology adoption take precedence over trialling over a short period. In this research, this concept was not considered a primary adoption-influencing factor. Observability is closely related to trialability and is discussed in the next section.

4.4.5 Observability

Observability was ranked the most important technology adoption factor by 2 (11.1%) respondents, second and third most important technology factory by 4 (22.2%) respondents on each rank and 5 (27.8%) respondents, the mode, ranked observability as the fourth most important technology adoption influencing factor, within the technology (T) element of the TOE-DOI framework. Figure 15 summarises the rank distribution.

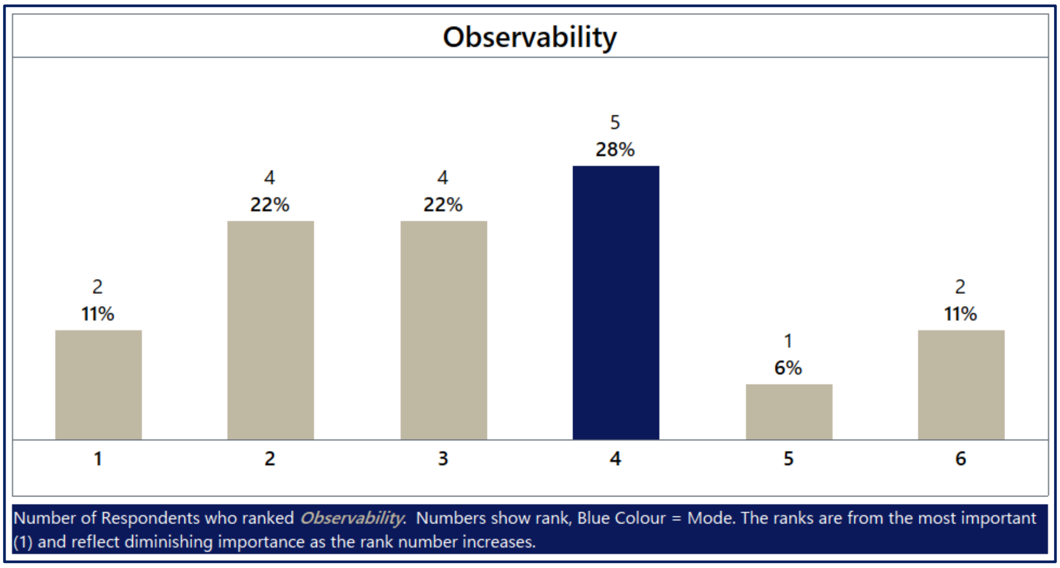


Figure 15: Rank of Observability as a primary technology adoption factor

As with other concepts, *observability* codes were developed and applied to interview responses. These are described in **Table 9** and the frequency of coding within the interviews is summarised in the column Grounded.

Table 9: Table of Codes – Observability Concept

Code	Definition	Grounded
Perceived successful fishing outcomes as a result of a unique technology	The extent to which successful observed results are attributable/ perceived to be technology-driven. (i.e. is technology the differentiator?).	10
Word of Mouth	Word of Mouth as a marketing tool – may be equated to the informal "Observability".	2
Targeted marketing through events and advertisements	Use of other marketing material to create technology awareness and visibility.	1

While knowing that a specific technology will add value to business operations is critical, seeing the success of another company's operations and attributing specific technologies to that success does not feature as primary adoption influencers. Of note, there is a difference in this light between the technology's ability to offer value which is a factor and the observation of results success in another company or set of operations. A fishing executive stated:

"You may have a way your operational structure is and that influences what technology you use. One rarely looks next door. You can understand the competitor but it's generally about your operations. So, you may see the neighbour using specific technology and think that using the same may help, but it may be working for the neighbour because they do something fundamentally different in their processes to what you do and therefore, you may not realise the value they do from using their technology." (Male, Fishing Operations Executive)

A major outcome from different respondents was the emphasis on internal operational efficiencies being esteemed more highly and thus more influential in technology adoption as opposed to looking at other companies and assuming that the technologies that gave them success would make the technology-adopting company successful too. The fishing executive further stated:

"Let us say I am running an experiment, and we are both cooking pasta with, the same recipe but I have one secret ingredient. Indeed, the pasta will come out similar but there may be slight differences due to the secret ingredient. So, you can maybe get a certain competitive edge in one aspect but it's not, really, a factor. (Male, Fishing Operations Executive)

The fishing executive further went on to state that the primary reason they adopted specific e-logistics technologies they currently use in their organisation was their internal needs and operational goals independent of the external competition. As such, the current technologies were assumed to be better than the preceding ones and their logic has proven successful, as stated by the fishing executive.

Word of mouth and other targeted marketing was mentioned in isolation, with one of the respondents suggesting that marketing technology as having been successful may influence their company to adopt the same technology. However, this was qualified by developer and fishermen partnerships which are further elicited within the organisation findings (Section 4.5) of the research. While *observability* may influence technology adoption, in the fishing industry, this was not considered a primary driver of that adoption.

4.5 Organisation Construct

The *organisation* construct of the TOE framework was ranked by the respondents as the most influential adoption factor, with eight respondents (44%) ranking this construct as the most important factor. The interviews further showed that the fishing industry considers people, their knowledge and understanding of the available technologies, their relationships and partnerships and their well-being as significant drivers of the decision to adopt e-logistics technologies. One respondent succinctly captured this understanding by stating:

> *The fishing career was previously not a desired one. It was simply a question of the choice of employer and not the choice of employment. Significant changes are being made to make the industry more attractive. (Male, Fishing Operations Executive)*

Figure 16 shows how the *organisation* as a TOE construct was ranked by the online survey respondents.

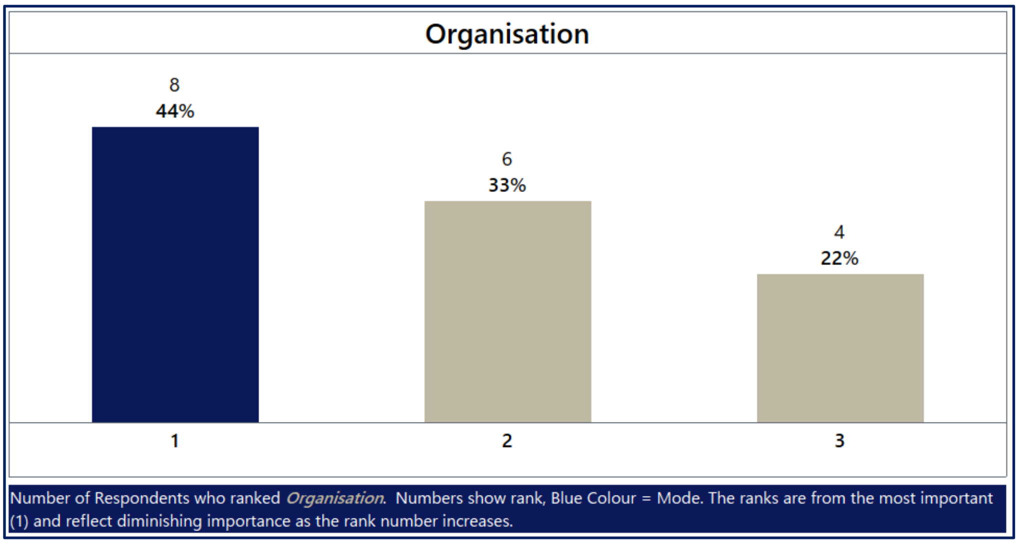


Figure 16: Rank of Organisation (aspect O in TOE) as an overall primary adoption factor

4.5.1 Top Management Support

The *top management support* concept was ranked the most important organisation influencing factor towards adopting e-logistics technologies by 11 (61.1%) respondents. In comparison, 7 (38.9%) ranked it as the second, third and least important adoption factor respectively. Figure 16 shows the modal rank as rank 1. In terms of online rank, the *top management* concept had the highest number of respondents ranking it as a primary adoption factor.

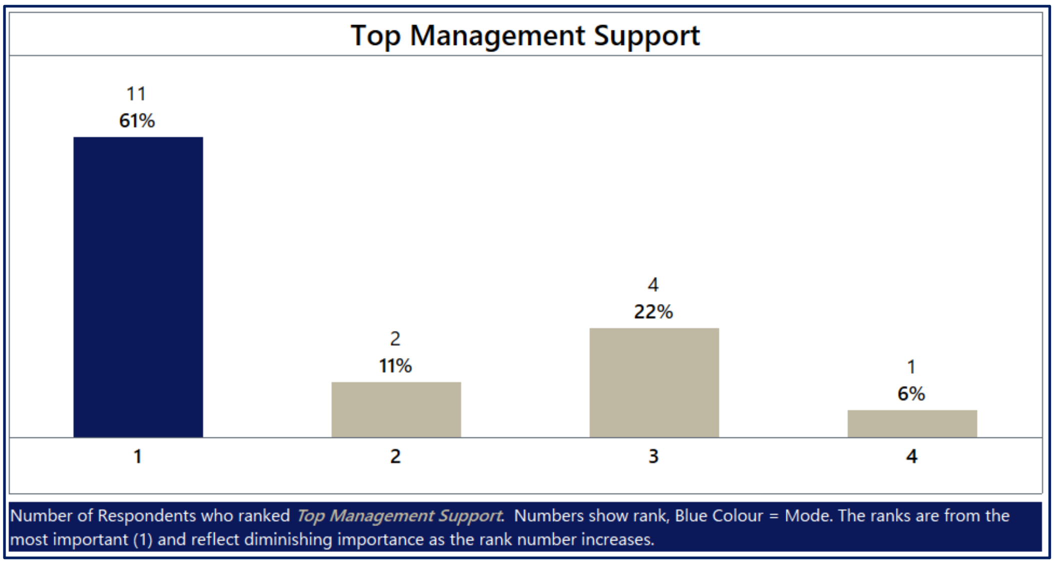


Figure 17: Rank of Top management support as a primary adoption factor in the organisation

A part of top management's undertakings is the management of risk. As such, respondents considered how management assumes or spreads the risk as a significant driver in adopting new technology. A male fishing executive put forward the notion that:

> *"There's also a risk element and the question is how one spreads the risk. In the adoption of new technologies, how does the business spread the risk? From a management's perspective, risk management, therefore, becomes a driving factor influencing technology adoption." (Male, Fishing Operations Executive)*

The primary importance of top management in e-logistics technology adoption is in line with numerous information systems (IS) innovation adoption findings (Ramdani & Kawalek, 2009). While not discussed exhaustively in the interviews, *top management* was acknowledged by respondents as a major driver of technology adoption. The discussions, however, dwelt on *absorptive capacity*, both in terms of capital and financial absorptive capacity, *slack* and *human resources*. These are further discussed in sections 4.5.2 and 4.5.3.

Ghobakhloo et al. (2012) and Caldeira & Ward (2003) assert that positive attitudes of top management have tended to influence technology adoption positively. Applying deductive reasoning, it becomes perceptible that top management has a primary role in technology adoption decisions as the bottom line priorities related to the economics of the organisation, identified under the *relative advantage* concept, are their responsibility. As such, affordability or unaffordability of technology decisions are driven by management. The consequences of inaccurate data affect data analytics (fisheries science and quota management), profitability and other material possibilities, all within the interest or control of top management. The extent to which this is a primary factor is further elicited in Chapter 4.5.2.

4.5.2 Absorptive Capacity and Slack

The *absorptive capacity and slack* concept were ranked by 7 (38.9%) respondents as the third most important adoption influencing factor within the organisation and 6 (33.3%) ranked this as the least important factor. The respondents highlighted the companies' ability to change staff and systems when necessary as the reason behind the rank. Although costly, the respondents considered this factor changeable toward overall business goals. Figure 16 summarises the rank of importance for *absorptive capacity and slack*.

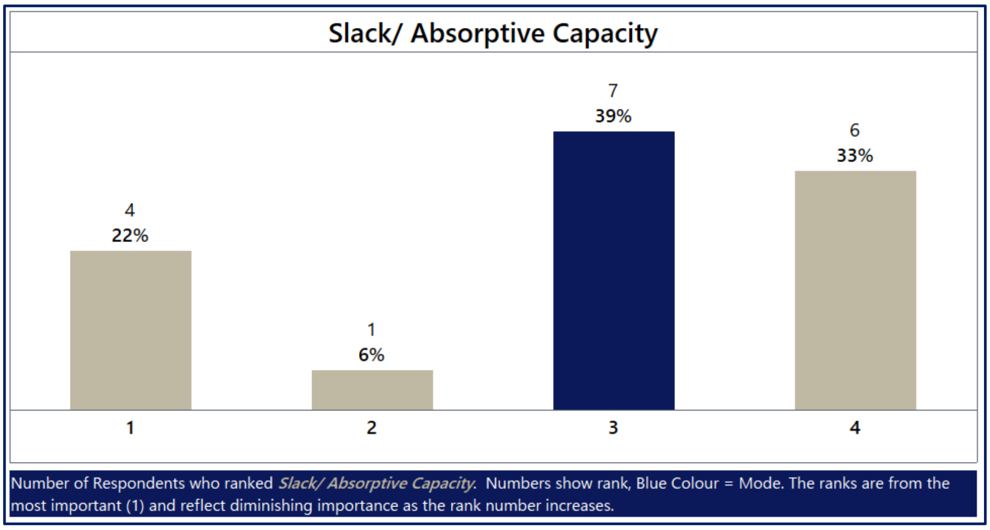


Figure 18: Rank of Slack and Absorptive Capacity as a primary technology adoption factor within the organisation

It is noteworthy that while *absorptive capacity* was not considered a primary driver in technology adoption within the online survey, respondents' comments qualified this construct as a primary driver. This divergence is discussed further in the following sections. *Absorptive capacity and slack* codes were developed, applied to interview responses and further interrogated for objective analyses.

Table 10 summarises these codes, the code groups, the definitions and the frequency of application to interviews.

Table 10: Table of Codes –Absorptive Capacity and Slack Concepts

Code Group	Code	Definition	Grounded
Resources availability	Availability of uncommitted resources - Human Resources	To evaluate whether the need for the technology is driven by having human resources to explore the technology. Does the company have the required skills among their personnel? Can the "untapped" skills be used?	4
	Availability of uncommitted resources - Financial Resources	To evaluate whether the need for the technology is driven by having financial resources to invest.	7
	The need for will (drive)	The need for willingness - though subjective is a real need. The prospective technology adopter must be willing to try new technology, learn to use it and improve their way of working to realise the most benefits from the technology	5
Inherent fishermen's biases codes	Conservative nature of fishermen	By nature, people in the fishing industry are conservation and therefore are not easily convinced that technology has a positive role in their business. (The generalisation that fishermen believe old ways are the best.)	9
	Cultural influence on technology use	This relates to the data culture built (or not built) amongst fishermen in the fishing industry	2
Human resources education and knowledge codes	Exposure to modern technologies	The degree to which the company or fishermen are exposed to the modern technological space.	10
	Fishermen education	The extent to which education impedes or enables fishermen to experiment with other technologies	9
	Knowledge of the benefits of data analytics	This relates to how the company or fishermen understand the benefits of data analytics.	8
	Knowledge of data analytics	This refers to how the company/ fishermen understand data analytics as a concept.	5
	Fishermen's experience with modern technologies	The degree to which the company or fishermen are exposed to the modern technological space.	3

4.5.2.1 Availability of Uncommitted Human, Capital and Financial Resources

The concept of *absorptive capacity and slack* included codes like the *availability of uncommitted resources, capital, and financial or human resources*. These were highlighted as driving the technology adoption decision during the interviews, contrary to the online survey rankings. These constructs were classified within a code group; *resources availability*. One company executive stated:

> *"This is necessary as, without the financial resources and the human resources, the technology cannot be applied. Fisheries are capital intensive and are a difficult sector but there's always opportunity. These dynamics*

must be captured in whether to adopt or not to adopt new technologies." (Male, Fishing Operations Executive)

The capital-intensive nature of fisheries suggests major once-off financial resources use periodically. As noted by the fishing executive, technologies that take into cognizance this reality and thus are offered at a more affordable rate are more likely to be adopted. Incidentally, technologies that may soften the intensity of substantial capital expenditures are more likely to be adopted. The e-logistics technology must thus show some economic value. Many organisations that do not have much financial flexibility to adopt these technologies have foregone the possible value of adopting these to take care of the daily operations' financial and capital demands. There needs to be some level of flexibility to explore and try new technologies and ideas, including financial flexibility.

A fishing association executive, augmenting this finding, further highlighted that all companies could have all other factors as identified within the interview process. However, at the end of the process would be an affordability discussion. The impediment to adopting the prospective e-logistics technology could be financial, thus suggesting that affordability and the availability of financial or capital and or human resources thus become pivotal in arriving at a technology adoption decision. The male fishing executive and consultant explicitly summarised this reality, stating:

"The only other comment that I have is that sometimes, on the software side of it, you know, it is priced in foreign currency because of where the technology is being developed. (A blockchain development company was used as an example). So they are using blockchain technology in a traceability space in commercial fishing. That's a system we would like to buy into, it looks to work very well, but that's USD1500 per month. It's priced in USD and you convert that to Rands and it is over R20 000 a month, just for some technology on traceability. That's a massive barrier to entry. As a South African fishing company, you can never afford that, so that inhibits a lot of the uptake. (Male, Fishing Operations Executive)

Further discussions on affordability highlighted the fishing industry's concern of cost versus the benefit of adoption regardless of the price tag of the e-logistics technology. The question would relate to whether the prospective technology is considered as being affordable to the company and whether the envisaged benefits would be worth the investment. A fishing executive relating the cost notes:

> *"So, from our side cost is most definitely a factor because you can go and spend more money than you could ever dream of making to try and get further. But you have to sort of know where to draw the line regarding your operation size and where you're going to just spend too much and you can't recuperate any of that money at all." (Male, Fisherman)*

This was an important realisation, in line with Rowan (2023) and Feng et al. (2020), who found that technical integration and interoperability across the supply chain are complex and negatively impacted by the lack of infrastructure, among other elements, including financial-related elements. Furthermore, Girard & Du Payrat (2017) found the cost of satellite imagery and equipment for smaller vessels as limiting the rate of technology adoption.

The need for willingness and will is closely related to the availability of resources, as stated by the respondents. A major take in this light is that regardless of how good a technology is, regardless of how the e-logistics technology addresses a need, there has to be a willingness from the fishers and other technology users to use the technology to realise the envisaged benefits. A female executive consultant noted:

> *"As a concluding remark, the most important factor is will. Everyone must be willing. Will is a fundamental influence and there are many examples when discussions stalled because of unwilling parties." (Female, Fishing Consultancy Executive)*

Another fishing operations executive stated the need for willingness and legislation by concluding:

> *"So, I think the adoption of technology is generally also driven by the willingness of both the guys at sea and the shore side and how willing they are to bring those onboard and also legislation." (Male, Fishing Operations Executive)*

Will, thus, plays an important role in any decision to adopt an e-logistics technology and is a necessary complement to other important factors identified. Taherdoost (2019) notes that a great technology may be designed and developed, yet, it is the people that ought to be involved and thus use it to ensure successful adoption and use, this being coherent with the interview responses and findings.

4.5.2.2 Inherent Fishermen Biases (Culture)

Closely related to will, were the inherent fishermen's biases. Within the Western Cape fishing industry and South Africa, fishermen have been considered as preferring to stick to ways of working that have previously worked for them. As such, newer technologies' adoption tends to be slow. Two codes were developed and analysed in this light; *fishermen's conservative nature* and *the cultural influence on technology use* within the Western Cape fishing industry.

A female technology developer with over ten years of experience in the fishing industry noted that as part of her experience, younger fishermen tended to adopt newer technologies more frequently than older fishers who had spent many years building experience on older technologies. She notes:

> *"I have experienced some resistance based on this. Usually, a younger crowd tends to be more receptive than people who are set in doing things how they do them." (Female, Fishing Technology Developer and Analyst)*

Furthermore, a fisherman noted that many fishers were not formally educated within their fishery. As such, introducing new e-logistics technologies would need to be approached from a limited knowledge assumption as opposed to an assumed exposure to modern technologies through formal education. A female analyst further elaborated on this issue, stating:

> *"It's very often a generational career (fishing) that is passed down, especially within the smaller kind of vessels and within the larger kind of industries. So, I think the fishermen that are, you know, fishing especially within the South African kind of community from my experience come with a lot of experience. So they've been around for a very long time within the field. (Female, Fishing Consultancy Analyst)*

The view augments Bellman et al. (2021) study on sociocultural concepts in systems analysis and modelling in that culture is a strong influencer of behaviour. In this context, fishermen's biases strongly influence e-logistics technology adoption. The respondents continued to mention some differences between fishers with vast experience and thus accustomed to their proven formulae of working and those from disadvantaged communities who do not necessarily have access to the education and tools available to more privileged fishers in South Africa. These groups are discussed in the next session.

4.5.3 Human Resources Education and Knowledge

The *education of fishermen* was also considered within the human resources context of the organisation. The codes developed and analysed within this context revealed the imperative nature of human-centred solutions development.

From a human resources perspective, interview respondents highlighted the lack of understanding of data analytics and, therefore, the benefits associated with data analytics as a factor slowing down e-logistics technologies' adoption. One business development manager stated:

"There's a lack of skill and understanding of those potential benefits." (Male, Fishing Technology Organisation Business Development Manager)

The respondent continued to state:

"South African fishing companies don't tend to see the value in e-logistics technologies when considering the need for a consistent stream of data. I don't think they are fully optimising opportunities to analyse the data and take advantage. They are not aware of the benefits." (Male, Fishing Technology Organisation Business Development Manager)

As an influencing action, therefore, creating awareness of data analytics, the benefits of exploiting data analytics and the technologies to arrive at this end are necessary undertakings. These findings align with those of Marciniak (2010), who found that lack of knowledge and unfamiliarity with the new technology are some barriers to ICT adoption in fisheries. It is, however, worth noting that while many technology adoption studies have found education as a primary adoption driver (Mazuki et al., 2012; Sule et al., 2009), within the South African context, however, respondents alluded less to education and more to exposure and experience with modern technologies. Therefore, the idea was to build familiarity with technology and that familiarity would improve the adoption of e-logistics technologies, regardless of the fishers' formal education level.

A female analyst notes this by stating:

> *Younger people most probably will be able to adapt very quickly because they're used to having this environment where you have to learn new systems and new technologies very quickly to kind of fit in with everyone, right? So, if it's about putting something on a tablet, it is very easy for people of a younger generation, however, the older generation are the ones who maybe would need several kinds of walkthroughs and would probably need some form of oversight in the beginning and maybe a manual or something to kind of get them good." (Female, Fishing Consultancy Analyst)*

This is further substantiated by a fisherman who states:

> *"For a lot of people, even for me in certain aspects, it gets a bit overwhelming (using a new e-logistics technology). I mean, if you haven't got the basic ability to operate, say, a modern smartphone, and then to try and take it one step further and try to get somebody to go log on to a website! I mean you can understand where I'm coming from with this. Excuse me. There are a lot of fishermen out there that don't even have smartphones, though they're still working with old cell phones. Guys are working with texts instead of WhatsApp and so you can kind of understand that there are people that are old school that do not want to change. They just pretty much are carrying on the way that they are, it's just too much for them to try and I wouldn't say it's a majority. I would say it's probably more of your older school guards that have been doing it their whole lives from when they left school or when they were still in school and they decided to become fishermen." (Male, Fishing Operations Fisherman and Captain)*

The views substantiate Hillborn (2007), who stated that understanding the behaviour of fishermen is a key driver to successful fisheries management. However, this view challenges the notion that formal education is an indicator of whether one will use e-logistics technologies. While one respondent alluded to small-scale fishers' education being limited, the majority of respondents consistently responded with skills comments and not formal education comments, with one user eventually stating:

> *"Look education, maybe isn't the right word. I think the right word would be 'experience' with the technology." (Female, Fishing Consultancy Analyst)*

The respondents highlighted education as relating to knowledge of e-logistics technologies instead of formal qualifications. This is an imperative finding in this research as fishers may have varied formal education qualifications yet possess skills and knowledge much harder to quantify. This also presents an opportunity for technology developers and vendors to develop solutions with some educative material with their technologies. This finding also supports Marciniak (2010), who identified a lack of knowledge, complexity of technology and unfamiliarity as barriers to technology adoption. As such, this may lead to a cultural distrust of technology. Respondents emphasised the need for technology to be accompanied by some support or guidance to mitigate this barrier to adoption.

4.5.4 Size of Business

The size of the business was not considered a direct adoption factor by the interview respondents. The modal rank of the concept of the *size of the business* was 4, ranked by nine respondents (50%). None of the respondents ranked the size of the business as a primary adoption influencing factor. Figure 19 shows a summary

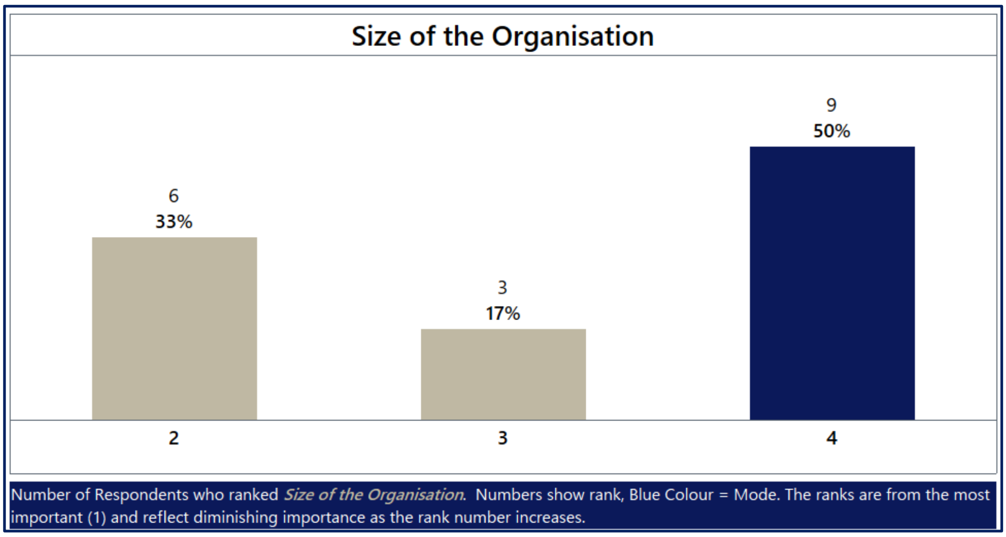


Figure 19: Rank of the size of the business as an organisation's technology adoption factor

Different organisations of different sizes use different technologies with varying complexities, from simple weather forecasting technologies to electronic logbooks, to sonars, to data analytics technologies for shore management of databases, to smart-weighing scales and other paper-to-digital technologies. The respondents, therefore, commented on the size of their company concerning their operational needs. Bigger companies considered economies of scale from increased fish production, while smaller companies considered affordability, with the theme of adopting technologies suited for their operations. The size of the business did not primarily influence the decision to adopt e-logistics technologies but highlighted the means available and the technology alternatives available for the different businesses to exploit. An association executive captured this succinctly by stating:

> *"I think that it's not necessarily the size of the company. It's their revenue. Right. So You could have an extremely small vessel, that is extremely lucrative and has high revenue because of the fisheries it participates in and how it goes about its fishing operations and maybe is catching species that are of higher value versus maybe a really large vessel that maybe doesn't have as high revenue. So I wouldn't always think of it in terms of the size of the physical vessel or the size of the company. But more importantly, like, how successful of a business operation that they run, how much money do they have in their pocket to afford to be able to pay for some of these things?" (Female, Fishing Association Executive)*

Furthermore, a fishing operations executive whose company is already using numerous modern e-logistics technologies stated:

> *"The size of our organisation did not play much of a role. The reason also we decided to digitise maybe was because the size of the organisation made it easier from an affordability perspective. And that's where size played a role." (Male, Fishing Operations Executive)*

In this research, therefore, the *size of the business* as a primary adoption-influencing factor is excluded, yet, because revenue, profits and physical vessels' deck infrastructure and the realities of the fishing operations, demand investment, the *size of the business* is considered an outcome of other TOE elements discussed in this research and not a direct influence to e-logistics technology adoption.

4.6 External Environment Construct

The *external environment*, aspect E of the TOE framework, was ranked the most important adoption-influencing group of factors by six respondents (33%), while 8 (44%), the mode, considered this aspect as the second most important and 4 (22%) considered the external environment as the least important adoption influencing group factor.

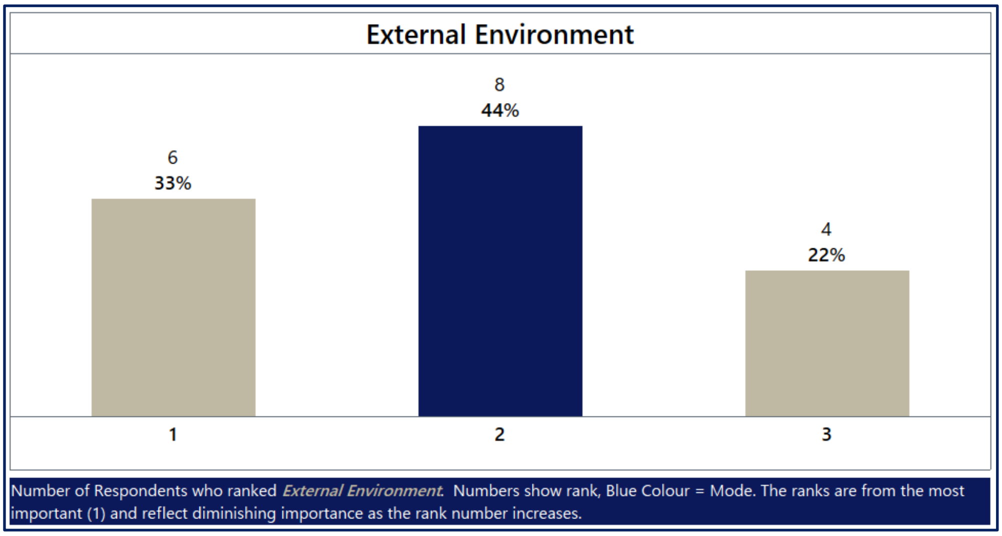


Figure 20: Rank of aspect E of the TOE framework

Three major groups of concepts were considered. These are *competitive pressure*, *external support* and *government legislature*. As such, codes were created and added to the relevant comments capturing these concepts. The following sections discuss the findings in this regard.

4.6.1 Competitive Pressure

Competitive pressure was ranked the least important adoption influencing factor by 8 (44%) of the respondents and this rank was the mode. 6 (33.3%) respondents ranked this the most important factor, while 4 (22.2%) of the respondents ranked competitive pressure as the second most important adoption influencing factor within the *external environment*.

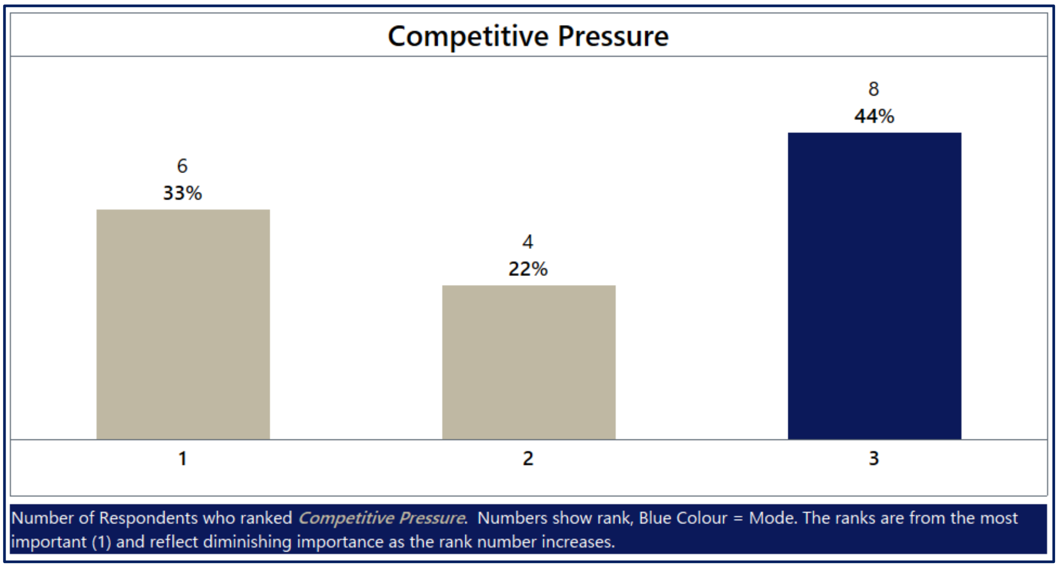


Figure 21: Rank of Competitive pressure

Three codes relating to *competitive pressure* of *cost-saving*, *time-saving and management* and *reliability improvements* were developed and considered in the analysis of this factor, with eight, five and one applications, respectively as shown in table X.

Table 11: Table of Codes – Competitive Pressure Concept

Code	Definition	Grounded
Cost-saving	How technology saves financial costs. Will the technology lower costs in relation to competitors?	8
Time-saving and management	How technology saves time-related costs. Will the technology improve internal processes, making the business more efficient in its operations over competitors? This excludes relative advantage internally.	5
Reliability improvements	How technology improves business reliability. Will the technology allow for business continuity? Will the technology enable quality assurance and a predictable supply of business goods (fish)?	1

A fishing company executive noted that reliability improvements had been realised in his company as internal efficiencies were improved. A major outcome of the discussion was the realisation that, while these improvements implied a competitive advantage, the industry competition was not the driver of the improvement but rather a comparative outcome of internal improvements. The executive who also possesses engineering expertise notes:

> *"In my company, I applied fishermen's knowledge together with engineering knowledge and some technology or technical knowledge and this has given our company a competitive edge by reducing the cost of developing our services and increasing the efficiency and reliability of our vessels across the board. We are perceived positively by our customers." (Male, Fishing Operations Executive)*

The realisation that internal improvements or internal efficiencies took precedence over competition operations was alluded to by other respondents. An operations executive, responding to the importance of competition in influencing the decision of what e-logistics technology to adopt states:

> *"You know, what competitors are doing is important, maybe if you look at it when it comes to rands and cents, but I can see where it may fit it. Primarily though, technology must enhance your supply." (Male, Fishing Operations Executive)*

As such, the fishing organisations highlighted that improving internal efficiency results in a competitive edge but did not consider competitive pressure as primarily driving their internal processes towards improved data analytics and other efficiencies. Instead of looking outwards, fishing organisations tend to look inward to improve internal operations, systems and processes.

4.6.2 External Support

External support was ranked the most critical adoption factor within the *external environment* by four (22.2%) respondents. In comparison, 10 (55.6%) ranked this aspect the second most crucial adoption factor, making this rank the modal rank. Four respondents (22.2%) ranked *external support* as the third most important rank.

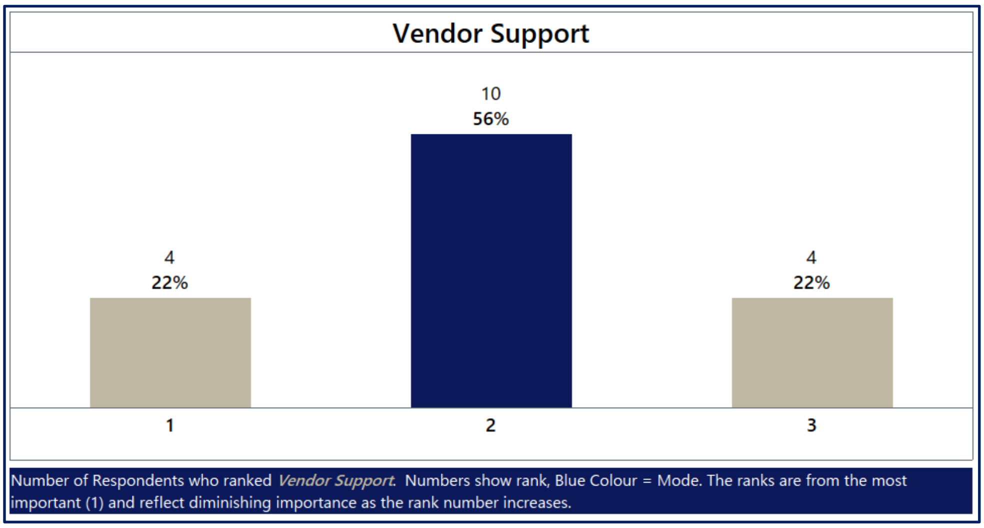


Figure 22:Rank of External support within the External Environment

Various codes were developed, applied and analysed within this context and **Table 12** defines these codes, highlighting the frequency of these concepts appearing in interviews.

Table 12: Table of Codes – External Support Concept

Code	Definition	Grounded
Partnership between vendors and fishermen	The solution lies in the two vested parties reaching a consensus that the technology works, the technology adds value and the technology is easy to use. This may involve multiple iterations of development, including applying design thinking techniques to arrive at the best fit-for-purpose technology.	11
Familiarity with the technology	The extent to which a good grasp of the technology is necessary before the full adoption thereof.	8
Confidence and trust building in the technology	This relates to how users develop trust in the new technology versus maintaining trust in the old proven methods, regardless of inefficiency.	8
Consultation and feedback between the technology provider and technology user	How users interact with technology providers/ developers and become involved in the development of the new technology.	8
Other social partnerships	These are partnerships between businesses, associations, and fishermen, outside of the vendor versus fisher partnership.	3
Availability of industry skills (vendor support)	This relates to how available vendors are to offer support related to different technologies provided in the market.	2

As an e-logistics technology adoption factor, the respondents identified the *pivotal partnerships between technology developers and vendors with fishing organisations and associations*, thus the development and inclusion of this code. There is a need to build these partnerships, encouraging trust and having multiple interactions. A fishing consultancy analyst notes:

> *"You've to trust this or you've done this wrong and it's more about them (fishers) getting their confidence in it, which they will then pass on to other people." (Female, Fishing Consultancy Analyst)*

Additionally, a fishing executive states:

> *"There also has to be some trust in the technology or application. As there is the transparency of the electronic systems or digital systems or e-logistics technologies, trust is improved and therefore the higher the positive changes relating to the adoption of that technology." (Male, Fishing Operations Executive)*

This trust was emphasised within the context of the partnerships and not only in trialling solutions, further showing that trialling was not necessarily the primary key to adoption but continued partnerships over the longer term, including the post-adoption of technology phases. Furthermore, the same fishing executive quoted above notes that this tends to be critical between businesses but is not necessarily an applied truth at the industry level. Businesses build trust among each other. Trust is defined as the willingness to depend on the specific technology in a situation where negative consequences are possible and includes elements such as risk, uncertainty, functionality to do the needed trust, operational reliability and consistency and the ability to fulfil an identified need in the expected manner (McKnight, et al., 2009).

Fishing technology companies considered these partnerships and encouraged critical onboarding and piloting phases to familiarise fishers with their technologies. As such, trialling the technology was considered less of a factor as the fishing technology companies emphasised partnerships throughout the technology development phase. Further analysis additionally revealed that building social partnerships to complement the technology support influenced e-logistics technology adoption. Respondents emphasised the role technology plays as a complement to fishing operations, highlighting the need for a consultative, iterative partnership between the development of technologies, their adoption and continued use. One executive explaining their e-logistics technology adoption growth within the Western Cape fishing industry notes:

> *"It's not about marketing but the structure of the organisation. We're a social company." (Male, Fishing Technology Organisation Executive)*

The executive further notes the fishermen's contribution to their technology development, that in the organisation's assessment, has seen tremendous success by stating:

> *"It's a good question, I think the co-design helps lower those barriers (barriers to adoption). People feel their input has been transferred into our software. Also, the fishers become the champions of this software and onboard their colleagues in a way. It's not about the technology but the onboarding program, the training and capacity building, it's about building the movement." (Male, Fishing Technology Organisation Executive)*

The fishing executive further elaborated on this comment as being driven by former fishers who have been involved in developing their technologies to assist, especially the small-scale fishers within the Western Cape fishing industry. This finding is in line with one of the six core components of a successful electronic logbook, as identified by Southern (2017), that identifies and acknowledges fishermen's contribution to the solution design process. An inclusive approach, therefore, ensures that the fishers trust and love the new technology while the vendors or technology developers provide efficient and relevant technology.

A different fishing operations organisation executive concludes the importance of building partnerships between companies and people by stating that people cannot be given what they do not know and be expected to use that. Instead, familiarity must be built and this is built through partnerships in the development, adoption, use and maintenance of the technologies. At the same time, partnerships must also include an understanding of the fishing operations. The best understanding can be obtained from those who partake in those operations, the fishermen and operations personnel. This complement is a sure approach to increasing the adoption of e-logistics technologies. He notes:

"You cannot give people what they do not know and expect them to use the technology efficiently. As such, one needs to also invest in ensuring that people know the technology, know how to use it and know how it benefits them. People do what they do and technology must complement that and therefore must be compatible with what people do." Male, Fishing Operations Organisation Executive)

People do what they do and technology complements what people do. The knowledge of the fishers and operations companies, the skills of the technology developers and the goal of sustained business continuity and profitability can be harnessed as these partnerships are strengthened.

4.6.3 Government Regulation

Government legislature was ranked the most important technology adoption influencing factor by 8 (44.4%) respondents. In comparison, 4 (22.2%) considered this as the second most important factor and 6 (33.3%) considered the government as the least important factor within the external environment. Figure 23 summarises the distribution of responses.

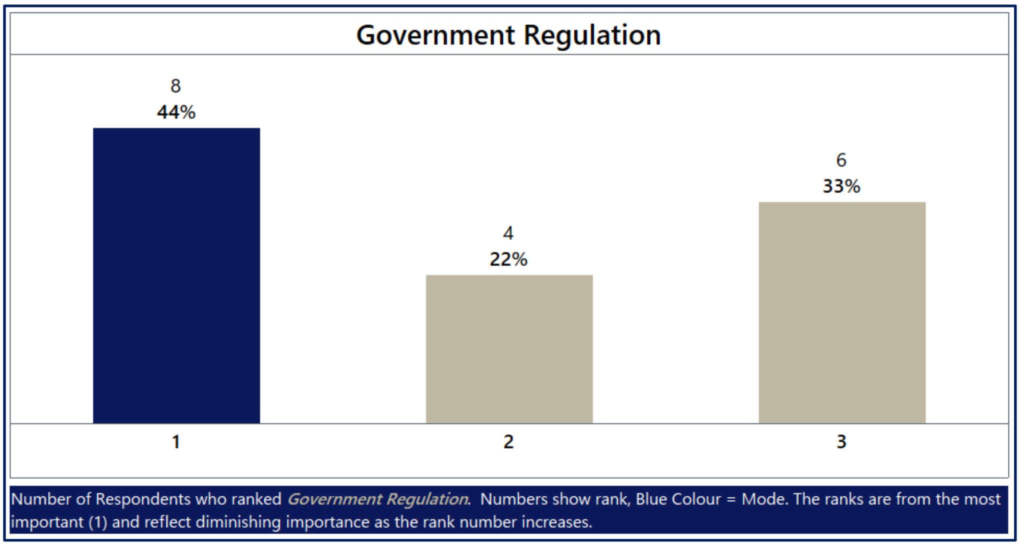


Figure 23: Rank of Government regulation as an adoption influencing factor within the External Environment

Government legislature was considered in terms of the laws relating to fishing operations, like quota management and fishing licenses and those relating to managing people and data. The following sections analyse the inputs provided and discuss the findings.

4.6.3.1 Fishing Standards and Governance

The *fishing standards and governance* group codes relate to government legislation of fisheries in terms of the reporting compliance requirements and other fishing laws protecting the fishing industry and resources, including the allocation of fishing rights and licenses. These were developed and applied to the responses. **Table 13** summarises the frequency of these codes derived from the analysis of the interviews.

Table 13: Table of Codes – Government Legislation Concept

Code	Definition	Grounded
Fishing events reporting compliance	The regulation needs to provide the government with fishing/ fisheries reporting.	5
Application of government incentives	The incentivising/ provision of benefits as certain technologies are utilised and certain standards are met.	5
Fishing rights allocation	The provisions made for quotas (or the absence thereof), provisions for small-scale fishers, and other rights related to commercial fishing waters.	4
Improved governance (regulation and security)	The protection and use of data (fishing, personal and other confidential data) by technology providers concerning regulation.	3
Unpredictability of regulation	The inclusion or absence and, or, change in the regulation of fisheries.	1
Availability of government skills	The availability or absence of necessary skills to complement the commercial fishing industry efforts, the fisheries scientists and the fishing technology companies.	1

Within the South African context, many organisations highlighted that they had not necessarily adopted e-logistics technologies because of being driven by the government but noted the reality that such a drive could have. They specifically considered best practices in more developed fisheries globally, like in the USA, Canada, New Zealand and some Asian markets. They noted the relevance of being able to report to the government as necessary and the need to achieve certain incentives that could be provided. As such, **Table 13** captures government influence based on the organisations' experiences and the organisations' conceptualising of a digital future. As a general e-logistics technology adoption influencing factor, *government regulation* was considered to play a significant role. The respondents highlighted the need always to maintain a legal fishing operation, thus implying an automatic influence of the government on internal operations. However, within the Western Cape industry, the different groups of organisations emphasised different elements of government regulation as influencing technology adoption. These are summarised in Figure 24. The government was seen to provide both a positive and a negative influence on adopting e-logistics technologies.

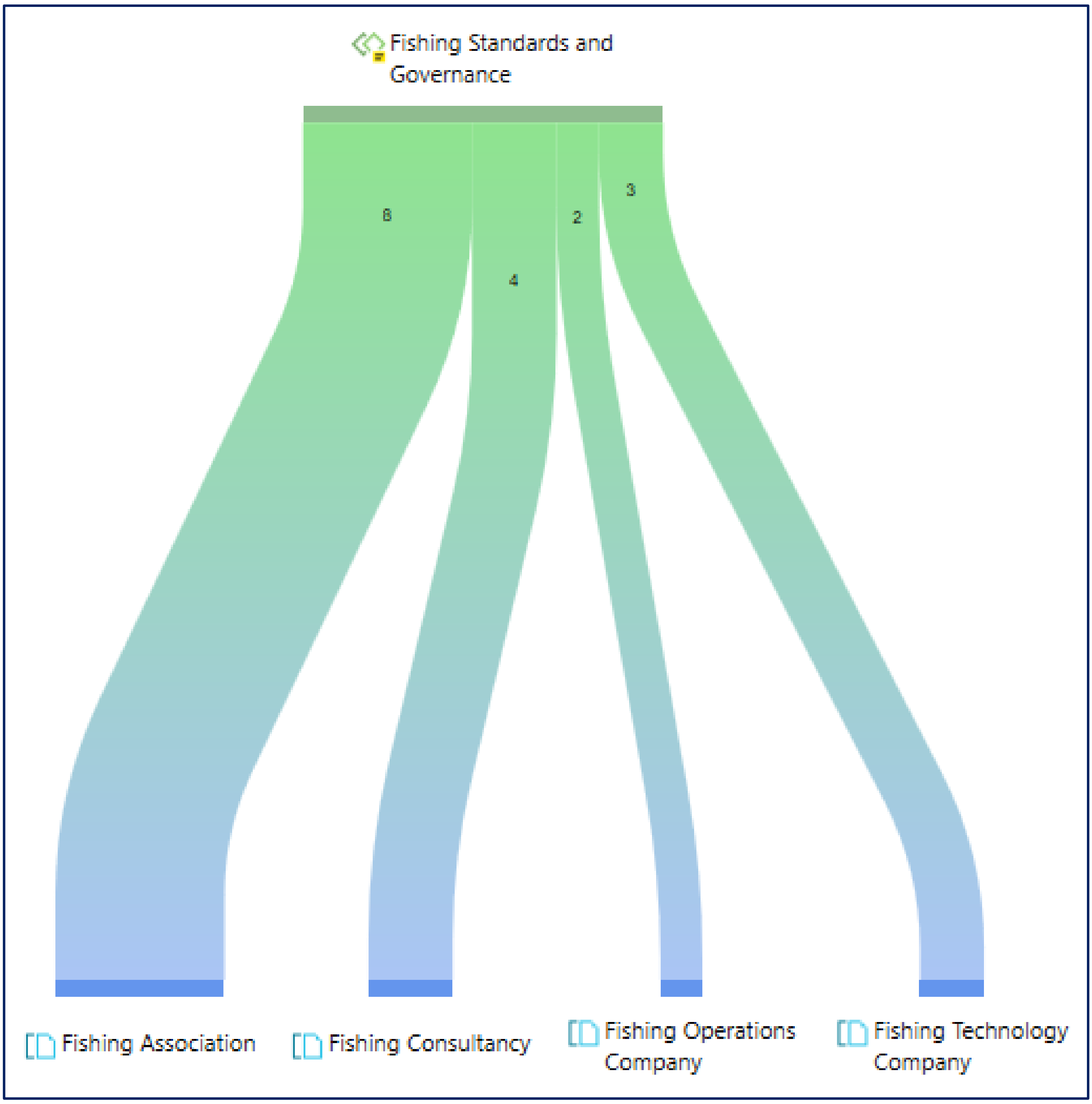


Figure 24: The importance of Fishing Standards and Governance by Type of Respondent Company

Fishing technologies and fishing operations companies noted that governments tend to have compliance needs that ought to be fulfilled. As technology is developed, therefore, there is a need to ensure that the technology will meet those standards and any other legal expectations. For example, when a government has a specific system and database structure, reporting on fishing operations ought to follow that logic, forcing technology companies to develop their solutions in a manner that embraces that reality. In South Africa, many fisheries are required to provide paper logbooks in specified document structures, thus diminishing the returns on digital data capture and reporting automation. A fishing association executive noted that:

"Yes, I think it's (government regulation) a primary factor because these processes are integrated, yet systems are outdated. There is no incentive for the industry to provide electronic data because they simply can't use it at present. They still want the notebooks, you know?" (Male, Fishing Association Executive)

An organisation thus may adopt e-logistics technologies but may still need to provide paper logbooks to the government authority to fulfil regulatory requirements. These organisations' digitisation activities are thus solely driven internally, while if the government were to force digital inputs, the adoption of these technologies would be driven internally and externally. A business development manager from a fishing technology company concluded his analysis of government influence by stating:

"If the government was more active, I mean data is playing a more pivotal role in society, it's all digital, I think adoption rates would be higher." (Male, Fishing Technology Business Development Manager)

Furthermore, respondents identified other factors relating to government regulation negatively impacting the adoption of e-logistics. These include the unpredictability of government regulation as it relates to fisheries in South Africa and the quota management systems in place for some fisheries. A fisher within the line fishery stated:

"Really, to be honest with you, I think one of the biggest issues with our sector is unpredictability. As an example, line fish licenses are issued periodically and as of 2022, the government is giving seven years on the right. Well, so basically you also have to figure out if it's worth investing more money into a sector that you're going to have for seven years. When you have to reapply, you don't know if you're going to get that permit and you could sit with a lot of money invested in the industry. In the past, a lot of people have lost their rights, even though it's their primary job." (Male, Fishing Operations Executive and Fisherman)

The influence of government, therefore, is in the fishers' decision to invest in technologies or continue with the status quo if cost is a factor, especially amongst the small-scale fishermen. The respondents noted that government incentives could positively enhance e-logistics technology adoption, augmenting Bolosha et al. (2022) whose findings arrived at a similar conclusion. The authors note that removing the uncertainties in business continuity and removing outdated legislation may incentivise businesses to adopt new e-logistics technologies, especially from a small-scale fishermen's perspective.

Further analysis into government influence on e-logistics technologies adoption revealed that human capital skills from the government might also influence government regulation and, therefore, technology adoption at an industry level. A female respondent noted that for fishing industry analytics to occur, government personnel must possess the skill to do so. In turn, this will influence the necessary technologies to enhance data analytics at the governmental level, influencing the legislation passed to companies to enable this data analytics. She noted that:

> *"I don't know if South Africa has that skill space in the capacity that it needs right now. I find that a lot of the fisheries scientists, while they are incredibly knowledgeable, they may not be as receptive to the new technologies." (Female, Fishing Consultancy Analyst)*

Further interrogation of the government's role in technology adoption revealed a possible legislative strategy to improve technology adoption in the Western Cape without necessarily imposing the specific technologies to adopt. This approach is discussed in the next section as a *standards-based approach to legislation* and how this may influence e-logistics technologies adoption.

4.6.3.2 Standards-based Approach to Legislature

Becker et al. (2020) noted a need for flexible information technology infrastructure to enable continual innovation. While government regulation is important, it must not stifle innovation. This implies a flexible legislative role government may play and is identified by one of the respondents, a fishing association executive, as a standards-based approach to legislation, where fishers, scientists, government, technology providers and customers, and all stakeholders within the fishing industry agree on fishing standards that in turn will inform and encourage technology development and not stifle innovation. The male respondent notes that:

> *"It's kind of difficult sometimes to write regulations for technology because the technology changes. You don't want to be too prescriptive. Maybe some*

sidebars or some rails, but then allow people to try different things and try different pieces of software and try different pieces of hardware. So if you write legislation, that is very, very specific, it doesn't allow innovation. It doesn't allow technology development. So it's important to provide what I would say, are standards-based outputs. (Male, Fishing Association Executive)

At the same time, it is imperative to note the need for specific and clear legislation. While adopting a standards-based legislative approach, the respondent noted the need for the legislation to attempt to be specific and clear enough to be followed. As such, policies developed ought to deliver clear expectations and transparency around how this data will be used and by whom. This clarity positively influences the adoption of e-logistics technologies that ensure that the specified regulation expectations are met. This finding was also highlighted by Smidt (2021), who emphasises the need for farmer-centred participation and collaboration when developing policy with particular consideration of small-scale farmers in South Africa.

4.6.3.3 Government's Complementary Role

While some respondents identified government regulation as a primary influencing factor for technology adoption, some identified the government's influence but did not consider the government as primarily driving technology adoption decisions. One of the association executives noted that operations efficiency and analytics innovation could not be driven by the government but by the companies that seek profitability or cost reduction and operations optimisation. As such, the role of government in technology adoption is limited to regulation and quota management, while the choice of technologies and their adoption is driven by internal company and association dynamics. The respondent notes that:

"Government tends to be slow and so drivers in my experience have been mostly driven by the technology or the business enterprise. Regarding the one traceability application we developed, we drove the entire process of development. Business and technology drive the technology development and the government may then complement our efforts." (Female, Fishing Consultancy Executive)

A male fishing operations executive notes that adopting e-logistics technologies is usually driven internally within the business to improve efficiency. As such, while other external factors may play a role, he notes that from his experience, it was a need for better data management and data analytics that influenced his company's decision on what technology and which technology company to utilise for different processes within their fishing operation. He notes:

> *"We're still utilising old technologies but together with modern 4IR technologies – that's the thing. One was not there to replace the other. It was more for the simplistic organising of the data. It's harder to organise if not digital. So it was more for filing or storing the data so that one does not need to go through multiple files and that information would disappear forever. So what we did was to do some analysis within the organisation and we passed this around." (Male, Fishing Operations Executive)*

It is imperative, as a complement, to note that, while at times, the government may not seem to directly influence a company's decision to adopt an e-logistics technology, it may indirectly do so through the standards-based legislation discussed and other legislation that may force the fishing organisation to adopt technologies that enable data analytics as required by the government. The creation and development of internal data warehouses and other analytics tools ensure that government needs relating to fisheries science may be more efficiently met, implying an indirect influence of the government on technology adoption.

4.6.3.4 Government's Influence and the 5 Stages of Technology Adoption

While the research did not consider relative factors' influence across the different organisations in the DOI classification of innovators, early adopters, early majority, late majority and laggards, some respondents alluded to the varying influence of government in this light. Government influence on innovators and early adopters was less than the government's influence on the late majority and laggards. One male executive, whose organisation had predominantly digitised their operations, stated:

> *You have some fishermen that we find are very progressive. They want to get involved in every type of pilot project in every type of new technology that's being rolled out. They have their ideas about how they would re-work*

and fit their warehouse to accommodate this new device or this new thing, right? That's like the one end of the spectrum and then at the very other end, it's like, I don't even own a cell phone, I don't want the technology. I just want to go fishing. I don't want to deal with all these other things and so it's almost like trying to identify how engaged the fishermen are with how they're being managed and how their data is being used. You get a big spectrum of fishermen, some are really engaged and some are not. (Male, Fishing Association Executive)

The fishing association executive highlights the possibility of varying e-logistics technologies appetite amongst organisations and fishermen within the Western Cape fishing industry. This appetite, in turn, may thus call for different measures, with some organisations willing to engage in pilots and other technology development projects and others preferring to stick to the old way of doing things. The executive continues to state:

"That last portion of fishermen that doesn't want to participate in anything – you can tell as many good stories as you want, and they're still not going to get into the program. They're still not going to volunteer. And so you do need, you know, you pilot tests, you maybe start to add more fishermen and your program grows, but to get the entire fishery, equitable playing field, equitable requirements across everybody, it needs to come from having regulations in place." (Male, Fishing Association Executive)

This comment concisely captures the government's role and influence in e-logistics technology adoption within the fishing industry. While other internal factors may drive some organisations, the industry-wide adoption of these technologies is only possible as the government introduces and develops regulations. A fishing technology developer and analyst notes:

"I think in South Africa, if there was even a further drive to push for electronic reporting, then there would be a greater uptake of elog (electronic logbook) technologies and certain business leaders would have been at the leadership of this." (Female, Fishing Technology Developer and Analyst)

A major outcome, therefore, from the engagements with various industry personnel was the limited role of government in being a primary adoption factor in some organisations while, for the laggards, being a primary driver. The discussions also highlighted the government's role in industry-wide technology adoption versus isolated organisations' technology adoption processes. This becomes a pertinent realisation within South Africa as some fisheries continue to report using paper logbooks, providing an opportunity for government-driven digitisation initiatives.

4.7 Data Security

In line with the findings of Taherdoost (2022), while TOE and DOI frameworks were amongst the most referenced for similar research, researchers used a combination of frameworks or added new variables to capture the operational realities. The concept of *data security* was investigated as a separate concept. Six respondents (33%) in the online survey identified data security as a primary adoption influencing factor. Three (17%) of respondents found this to be the least influencing factor. Figure 25 displays the distribution of the respondents' ranking of the construct *data security*.

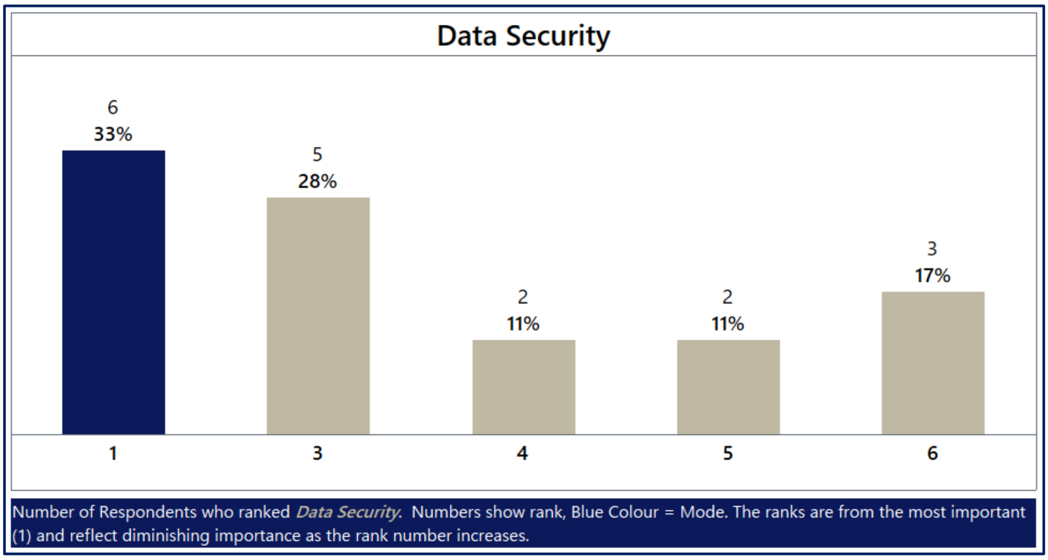


Figure 25: Data security

Further insight into the online responses was obtained during interviews where the respondents qualified their online responses related to *data security*. The *data security* concept was further disaggregated with *fishing data quality* related to data security and *fishing data governance*.

4.7.1 Fishing Data Quality

Data quality is defined as the degree to which the data of interest, in this instance, fishing data satisfy the laid down requirements, are free from errors or flaws and are suited for the intended purpose (Hassenstein & Vanella, 2022). The *fishing data security* concept was analysed in terms of the data quality throughout the data life cycle from retrieval offshore to integration and analysis, storage and archiving inshore. The codes in **Table 14** were ideated and applied.

Table 14: Table of Codes – Data Security Concept

Code	Definition	Grounded
Hacking	How the technology protects company data from those that may access it without due authorisation. Do companies feel this will break or the technology adds a layer of security?	2
Data manipulation	How the technology limits data manipulation by fishermen (e.g. automated winches will always record an event as it happens while a fisher may have changed the times and location of the event).	1
Data loss	This relates to the disappearance or unavailability of data that previously was available e.g. loss of data due to deletion, viruses or other forms of negligence.	4

Data loss was the most emphasised element within the *data security* concept. The management of data in terms of avoiding loss through lost paperwork and other means can be more efficiently managed by e-logistics technologies. In this light, *data security* becomes a primary factor driving the decision to adopt new technology. A male fishing operations executive notes:

> *"Uhm, so there are two parts and one is in terms of how our information is used and how someone gets hold of it and the other is in terms of not losing data. Definitely, the 'not losing data' is very important." (Male, Fishing Operations Executive)*

A female association executive further states, emphasising data security in terms of protecting the data from hacking and other malicious activities:

> *Data security or data protection is critical. We've had a few hacking incidences and these have ended in huge costs for businesses, whether to pay a ransom or losing of the data altogether. The security of fishing data is a major driver in decision making as it protects the company's operations and profitability strategy." (Female, Fishing Association Executive)*

An element of security as it relates to preventing data loss and an element of data protection as it relates to the implementation of protective measures to data were emphasised. As noted by the respondents, technologies that can show this benefit are more likely to be adopted. Consequently, e-logistics technologies must reflect utility in preserving data and protecting the business from data loss while providing the data as and when needed within the shortest timeframe possible. Fishing data is used to inform fisheries science and, therefore, fisheries management, thus the need for data to be available when needed. E-logistics technologies enable these benefits and *data security* is identified as an adoption influencing factor.

4.7.2 Fishing Data Governance

A discussion on fishing data governance as it relates to *data ownership* and *data confidentiality and access* ensued. Firstly, the respondents highlighted challenges regarding data ownership and secondly, accessing the information. These two concepts were developed and coded accordingly.

4.7.2.1 Data Ownership

The issue of data ownership was raised as relating to what technology organisations may share or make use of, versus what fishers would consider as private data for their fishing expeditions e.g. fishing location data. A fishing operations executive noted:

> *There also has to be some trust in the technology or application. As there is transparency of the electronic systems/ digital systems/ e-logistics technologies, trust is improved and therefore the higher the chances of adopting that technology. (Male, Fishing Operations Executive)*

E-logistics in this end, therefore, ought to ensure that data remains within the ownership of the data-generating company while the technology facilitates data capture, storage, transmission and analysis. This understanding is closely related to the concept of data access and confidentiality as it relates to data security and is further elaborated on in Section 4.7.2.2. Alluding to a similar understanding, a fishing technology executive notes:

> *"There's a clear difference between data that belongs to the fisher and data that may be shared." (Male, Fishing Technology Executive)*

The fishing technology executive made this comment, explaining his proprietary technology adoption growth amongst fishermen as being driven by transparent data governance policies. As such, e-logistics technologies that appreciate the sensitivity of fishing data, provide transparent fishing governance mechanisms and thus gain trust amongst the fishermen are more likely to be adopted.

4.7.2.2 Confidentiality and Data Access

As noted by the respondents, a continually sensitive issue relating to fishing data is the fishing location data. In encouraging e-logistics technologies, there must be clear protection of sensitive fishing operations data like the fishing location by providing clear rules of who accesses data, when and how. A fishing executive from a technology company notes:

> *"The app (one of the applications developed) will give an approximate location of where fish was caught, and will also provide financial management abilities so that fishers can manage their accounts and their transactions. All those data are not shared with the public unless in an anonymised nature." (Male, Fishing Technology Executive)*

As such, the executive notes, his e-logistics solution was adopted by fishermen because, amongst other benefits, it promoted data security and transparent data governance on how data is collected, stored, reported and used.

Closely related to *data security* is *data integrity*. While data security emphasises the protection of digital information from unauthorised access, corruption and theft (IBM, 2022), *data integrity* informs part of the data security concept and emphasises the consistency and trustworthiness of the data, complementing data quality in terms of accuracy, timeliness and completeness (Monczka, et al., 2009). If one secures the database, the integrity of the data is subsequently protected as well. Companies want to protect and secure their data while maintaining the integrity of their data and analytics endeavours within the industry, further placing *data security* as an adoption influencing factor.

Two technology developers further elaborated on security-related influence, stating that, theoretically, every organisation assumes their data will be protected and data quality and integrity maintained. While organisations are not actively emphasizing security, a lack of security will ensure that the technology is not adopted. The first developer and analyst states:

> *"In my experience, I found that theoretically it is a driver more than in the practical terms." (Female, Fishing Technology Developer and Analyst)*

Further augmenting the implied assumption of data security by fishers and other technology users, the second developer and analyst notes:

> *"I would think they would assume their data is secure. For them it would be, they would assume regardless of the technology they adopt that their data is secure. For them it's a no-brainer, it has to be that way. If you don't protect your data it will be an issue." (Female, Fishing Technology Developer and Analyst)*

While *data security* featured as an important factor in technology adoption, there remained a question of how one would police *data security*. Some occurrences are inevitable. E-logistics technologies may be hacked, although improving security reduces this possibility. The systems may sometimes be manipulated by users and, therefore cannot be failproof. As noted by a fishing operations executive:

> *"Every person will say we need data security. As an example, when you attend the scientific working groups meetings, you sign a code of conduct and it includes data security and a whole bunch of things but that's very difficult to police." (Male, Fishing Operations Executive)*

While nothing may be completely secure, reflecting some level of security measures within an e-logistics technology improves the possibility of the technology being adopted. Nwaiwu et al. (2020), in their discussion of the impact of security and trust in the intention to adopt technology, found that prospective technology users need assurance of security and trustworthiness of the technology to build confidence in the said technology. The study considered technologies that collect, store and transmit user data, augmenting the respondents' comments discussed. Furthermore, Feng et al. (2020) and Rowan (2023) found that lack of standardization and harmonization, data integrity, and data security risks impede the adoption of e-logistics technologies and the development of data-driven operations. As further noted by Nwaiwu et al. (2020), many studies show the importance of security and trust as factors that could either directly influence behavioural intentions or indirectly influence other independent variables, such as perceived usefulness and ultimately lead to a positive influence on behavioural intentions. Jokonya et al. (2014) advocate for the involvement of all stakeholders in adoption endeavours, enabling partnerships amongst all stakeholders to build the needed trust and the adoption of technologies thereof as a result.

4.8 Ethical Challenges

An additional concept was the reality of *ethical challenges* arising from the development and adoption of e-logistics technologies, especially within the South African context. How the technology displays fairness and acts as a complement to personnel within the fishing organisation and government may influence whether the e-logistics technology will be adopted. This relates to the ethics surrounding fishing technologies, their development, use, partnerships and overall contributions to society. One of the technology company executives explained how the fishing industry favours some technologies over others because of the ethical standards around development and use by stating:

> *"The onboarding is critical. It's not a one-to-one relationship but a community relationship. The idea is to build collective action, build a movement, build a brand of small-scale fishers, providing premium quality, ethically sourced, fully traceable, socially just fishing package." (Male, Fishing Technology Executive)*

The community relationship and technology developers' partnerships with fishers are featured in conversations with all stakeholders. As a technology influencing factor, as Isaac et al. (2020) found, community partnerships are a necessary foundation for encouraging technology adoption. The executive further notes:

> *"It's not just about competitive advantage but about fairness as well. It's about moving small-scale fishers from informal marginalised spaces to a state of social entrepreneurship." (Male, Fishing Technology Executive)*

Technology that portrays an ethical image, one that supports fishers and fishing organizations in improving their fishing experience and profitability, is thus more likely to be adopted. However, not all e-logistics technologies serve the described purpose, but some may, in improving processes, result in loss of employment and, thus, loss of income by certain fisheries personnel. An analyst notes this by stating:

> *"In South Africa, one question to ask is; How many workers am I going to lose? What is my employee turnover? Employment is a hot topic in South Africa. We have a really high unemployment rate. The rise in technology, specifically within the operational fishing sector is not always viewed in a positive light as it can be seen as a method or process to reduce staff numbers and replace workers. As an example, consider Electronic Monitoring (EM) technology, sensors and automatic processing plants." (Female, Environmental Consultancy Organisation Analyst).*

Ethical issues outside of the fishing industry thus influence the adoption of e-logistics either as a barrier or, in some instances, as a positive influence. Technologies that support human involvement and contributions to the overall fisheries management are thus more likely to be adopted. On the contrary, technologies that are seen as replacing humans may be avoided. Like many nations globally, South Africa strives for more socially-just distributive outcomes (Horner & Alford, 2019). As such, e-logistics technology opportunities ought to consider small-scale farmers, rural families, women and other disadvantaged groups within society (Smidt, 2021; Begashaw et al., 2019).

In separate interviews, one fisherman and one fishing operations executive made similar comments relating to South Africa's political climate. The major premise presented was that affirmative action amongst other laws in the country has enabled some groups of people yet, disabled other groups of people. This, in turn, has disincentivised investment into longer-term capital-intensive e-logistics technologies by some groups. The fishing operations executive, who mentioned that he started fishing at a tender age and carried over his father's legacy notes:

> *"We have animosity in society, black trying to rid of whites and vice-versa, through whatever means and for whatever reasons." (Male, Fishing Operations Executive)*

The executive notes that this presents an ethical challenge in that, on one end, there are pertinent social justice realities to be resolved, yet, at the same time, experience and skill in fishing are independent of such realities. A fisherman, commenting on a similar reality notes:

"I'm sure that you're aware that we're very nervous about the current license applications. We, basically, are just living month to month, not sure if we're going to get our permits and what the new regulations are going to be put into place. So the moment is very, very uncertain. A lot of people have lost their rights even though it was their primary job." (Fisherman, Fishing Operations Organisation)

Highlighted in these comments was the uncertainty of license renewals for some fisheries and the reality that some laws may automatically exclude some groups of people in license renewals or quota management, further disincentivising investments by temporary license holders into longer-term e-logistics technologies. Government regulation and the prevailing social justice environment thus play a role in determining whether or not to invest in some e-logistics technologies.

4.9 The most emphasised Constructs by Type of Organisation

The diverse organisation types allowed a window into the assumptions and areas of importance that the different stakeholders within the fishing industry may consider for adopting e-logistics technologies and developing data analytics. In this analysis, respondents' organisations were grouped into four types of organisations. The sections show how codes and their code groups continued to avail themselves in discussions based on the type of organisation in the discussion. As shown in the following sections, different groups of organisations emphasised different aspects of e-logistics technology adoption factors, each emphasising their input based on the relevance of the factor to their environment.

4.9.1 The Fishing Operations Organisation

This refers to organisations directly involved in daily fishing operations of going offshore to catch fish and processing these into products for consumers. Figure 26, a Sankey diagram, summarises the frequency of code groups as codes were applied to responses. The higher the frequency of application, the thicker the size of the corresponding bar.

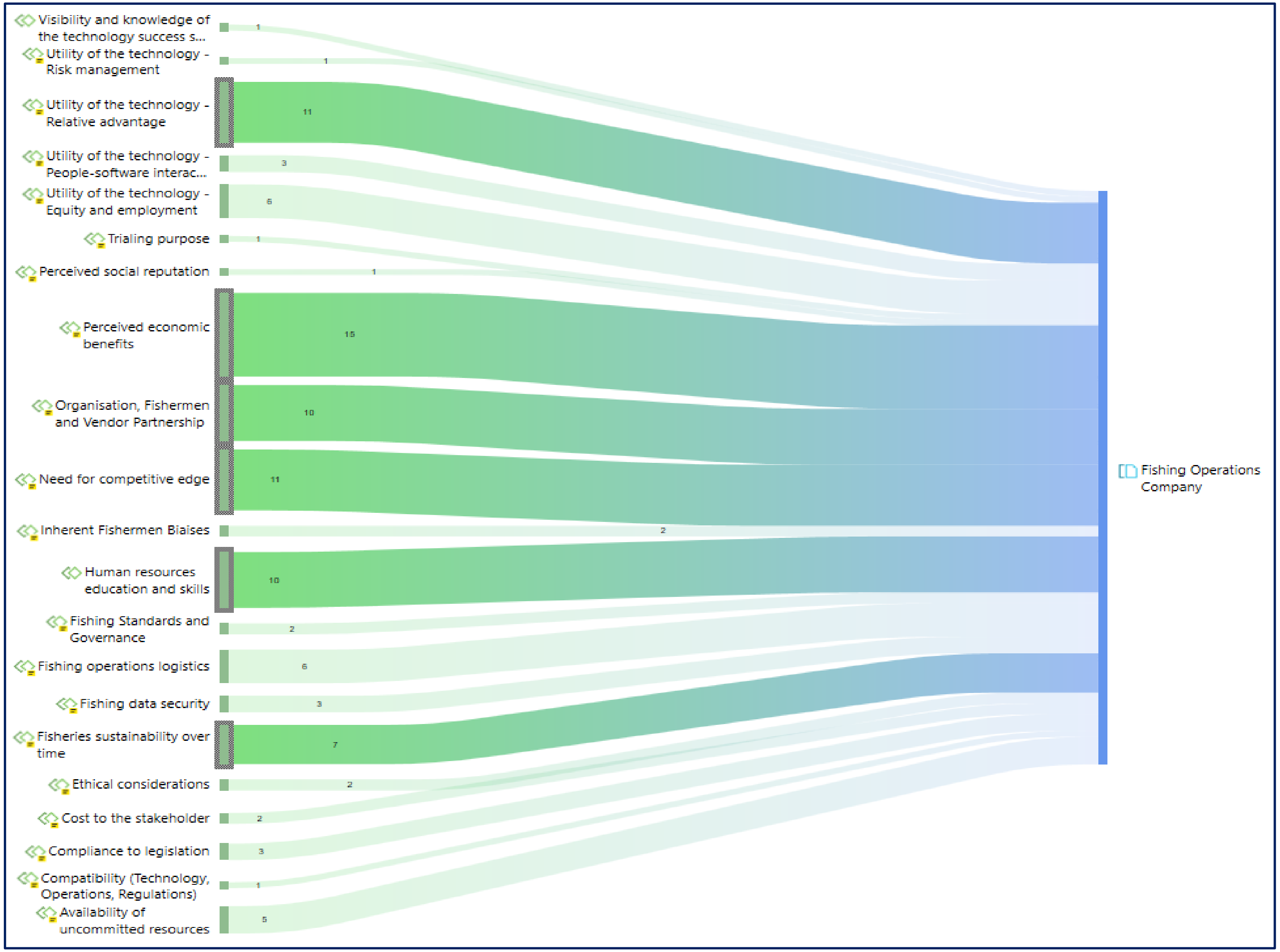


Figure 26: Sankey Diagram of the Fishing Operations Organisation's Emphasis

Perceived economic benefits, a concept within the *relative advantage* construct, was the most common theme (code group) in the responses from fishing operations companies. This included discussions captured in codes such as *improved revenue, profitability, cost-reduction, affordability, perceived productivity improvements and access to diverse distribution network*s driving the decision to adopt technologies. Additionally, both concepts within *the relative advantage* concept and *the utility and sustainability of the technology* thereof were also emphasised. Other concepts included *human resources education and skills, partnerships amongst fishing stakeholders* and the need for a *competitive edge* as drivers of technology adoption. Of note here is that fishing operations organisations considered a competitive edge as a result of internal operational efficiency improvements, thus being a result or outcome as opposed to driving e-logistics adoption.

4.9.2 The Fishing Association

In this group are respondents from various fishing associations whose comments captured their associations' drivers of e-logistics technologies adoption. Fishing associations are legally recognised industrial organisations or bodies. Figure 27 summarises the code groups' frequencies as codes were applied to discussions with fishing associations' personnel.

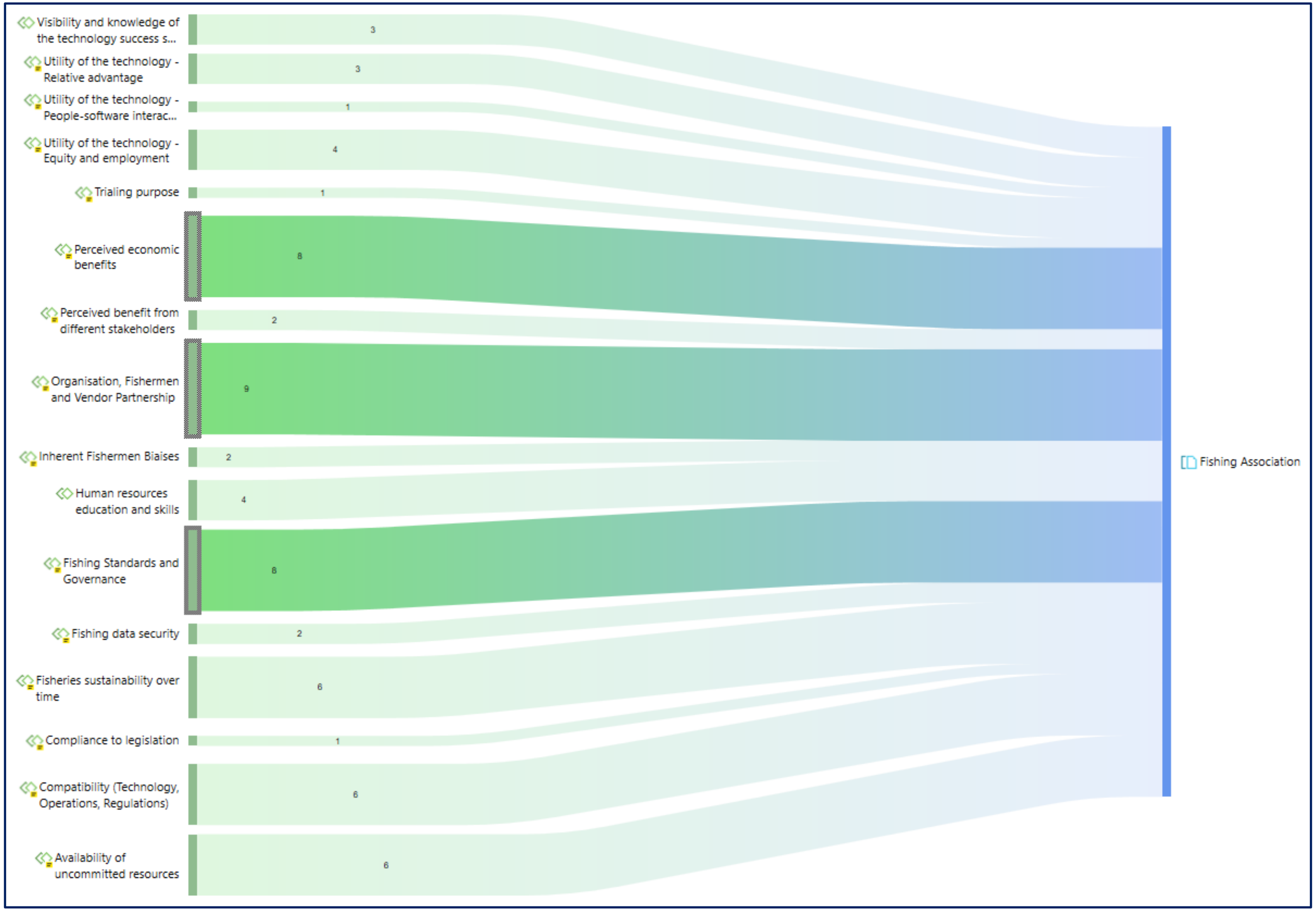


Figure 27: Sankey Diagram of the Fishing Association's Emphasis

Perceived economic benefits, *partnerships between fishing industry stakeholders* and *fishing standards and governance* were frequently alluded to in responses. The respondents also emphasised *fisheries sustainability, the compatibility of e-logistics technologies with fisheries operations processes and regulations* and the *availability of uncommitted resources*. Fishing associations emphasised the relationships between various stakeholders and how these, in turn, may be used to enhance internal organisations' fishing operations processes and government regulation, all necessary for the continued sustainability of the fishing industry. Fishing associations bring together various personnel and organisations in the industry who share similar fishing operations' objectives and are involved in the fishing of similar species or in using similar methods of fishing. The emphasis highlighted the inter-connectedness of stakeholders, the unity of purpose and the mutual objectives relating to the continued existence and development of the fishing industry. Technologies, therefore, that capture this interconnectedness are more likely to be adopted.

4.9.3 The Fishing Technology Organisation

This group of organisations included all respondents who develop e-logistics technologies or provide those to the fishing industry, primarily providing technologies to fishing operations companies and associations. Figure 28 summarises the code groups applied to fishing technology companies' respondents.

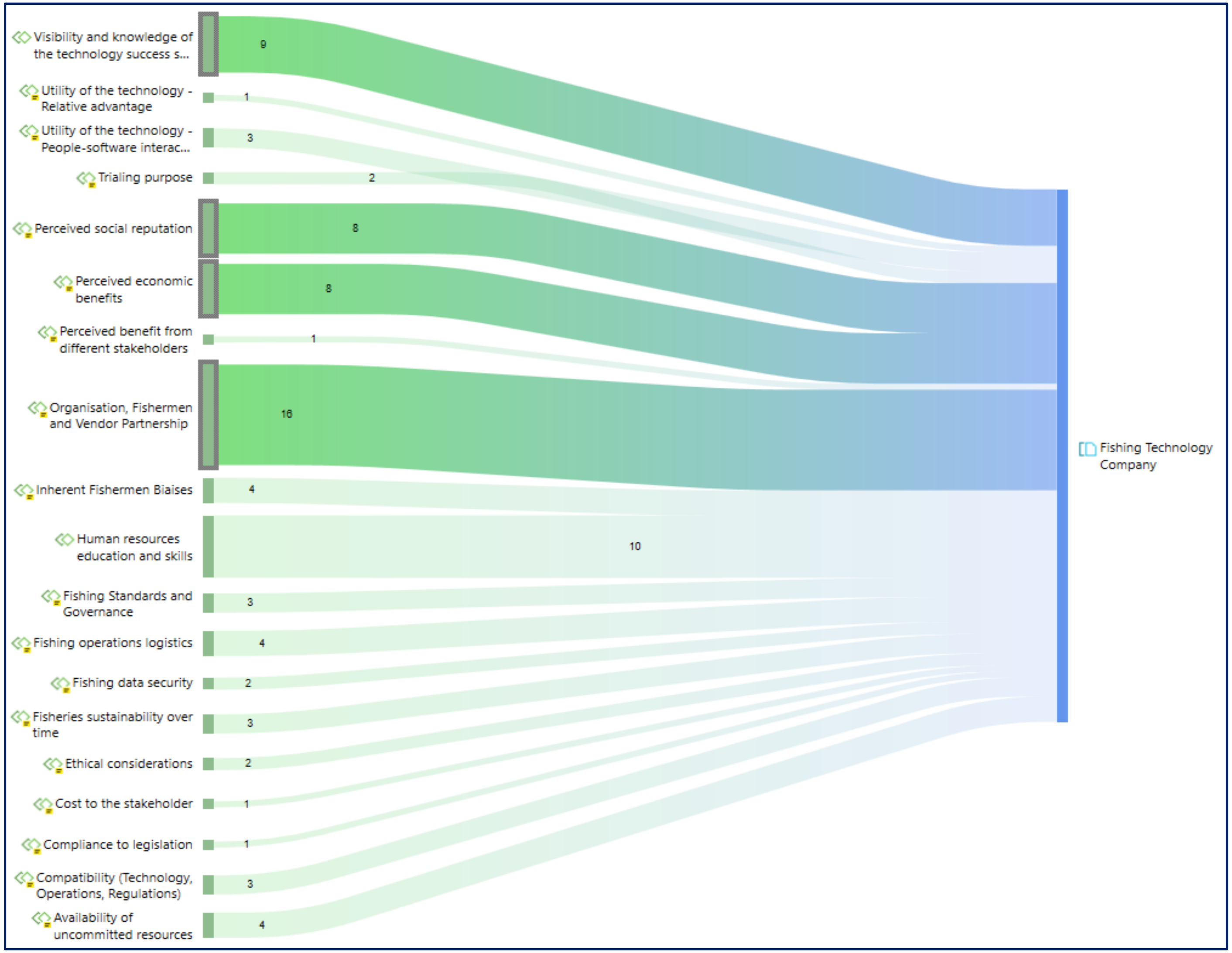


Figure 28: Sankey Diagram of the Fishing Technology Organisation's Emphasis

Partnerships between different fishing industry stakeholders were outrightly the most common theme for this type of organisation. The respondents emphasised the uniqueness of fishing operations, the nature of natural resources management, including fisheries science and the availability of innovations in other industries that may benefit the fishing industry. In terms of e-logistics technology adoption, these companies emphasised their experience in providing their technologies to the industry and the possibilities available due to technological advances. They concluded that their solutions have successfully been fit for purpose in addressing the industry's needs. These needs, they noted, include *perceived economic benefits*, the organisations' *social reputation* and *general visibility and accountability* of the solution provider to the industry.

4.9.4 The Fishing Consultancy

Fishing consultancy organisations refer to those that offer consultancy services within the fishing industry in any related capacity. Figure 29 displays a summary of the frequencies of themes coded.

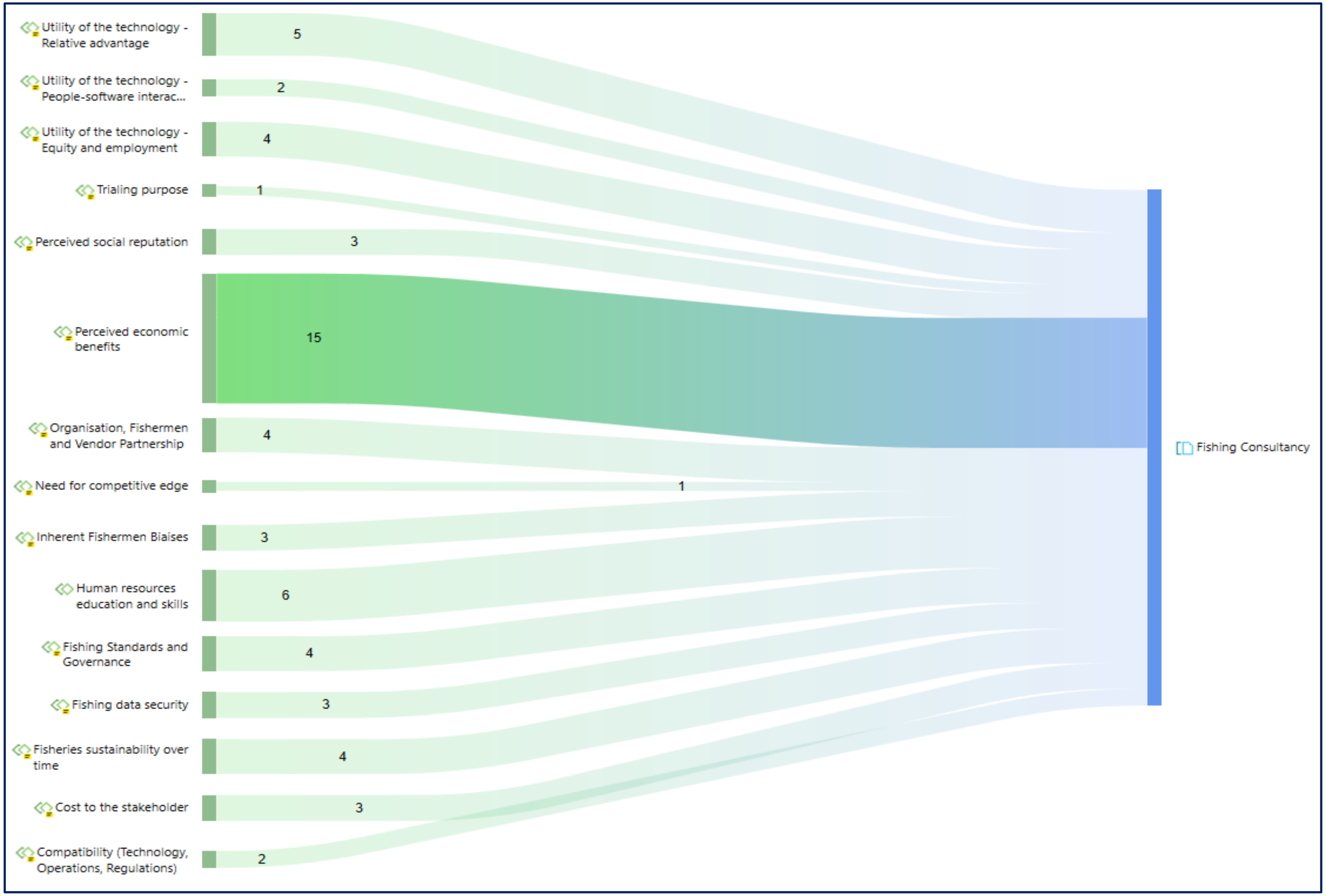


Figure 29: Sankey Diagram of the Fishing Consultancy's Emphasis

Perceived economic benefits, once more, were the most prevalent code group. The fishing consultancy emphasised the need for e-logistics technologies to show value by ensuring measurable financial benefits with their adoption. The respondents asserted that within their organisations, while technology adoption varies from one company in the association to the next, technologies that displayed possibilities of quantifiable financial returns (or cost reduction) at affordable price tags were more likely to be adopted. These included technologies like sonars, electronic logbooks, cameras for electronic monitoring, traceability solutions and other fish processing technologies like smart weighing scales.

4.10 Chapter Summary

In this chapter, the survey participants' demographics were described. Furthermore, their respective roles, the number of years in their companies and the number of years in the fishing industry were also discussed. The organisations were grouped into four types: fishing operations, fishing association, fishing technology and fishing consultancy organisations. The online survey rank responses were analysed and included with the interview qualitative responses analysis. Verbatim respondents' comments were included to elaborate on the analysis outcomes and reasoning behind the drawn conclusions. Furthermore, a brief analysis of the types of organisations and their emphasis on influencing factors were included. This provided a lens into the relevance of identified factors to all stakeholders. The findings and discussions were analysed to inform the Western Cape fishing industry's e-logistics technology primary adoption influencing factors, elicited in Chapter 5.3.

Chapter 5: Conclusions and Recommendations

5.1 Introduction

The previous chapter discussed responses from both the online survey and the qualitative interviews. The chapter, following various analyses, identified primary e-logistics adoption factors and separated those from the less influential factors based on the research responses.

This chapter synthesises the primary factors driving e-logistics technology adoption into a framework. Section 5.2 discusses how the objectives outlined at the outset of the research in Chapter 1.4 were achieved. Section 5.3 picks up from Chapter 4, developing an e-logistics technology adoption framework for the Western Cape fishing industry following the research contributions of the industry personnel. The chapter further includes statements on the validity and reliability of the research, the contributions and limitations of this research, and concludes with recommendations for future research. As shown in Section 5.3, there is a possibility to use this framework in other similar environments outside of the Western Cape, having considered the context within which the research has been conducted.

5.2 The Attainment of the Research Objectives

The research undertook to fulfil five key objectives and the fulfilment thereof is discussed in the next section. The research objectives and questions were identified in Chapter 1.4 and the research instrument adopted towards the realisation of these objectives was presented in Chapter 3.5.

5.2.1 Objective 1: To identify available e-logistics technologies for data analytics within the fishing industry.

The first objective was achieved by undertaking a literature review, with research related to this objective summarised in Sections 2.1, 2.2, 2.3, 2.4 and 2.5. An overview of the history of the fishing industry, the necessary data analytics and the status quo in operations and trends as they relate to the Western Cape are given. A major highlight of these sections is the state of fisheries vis-à-vis the state of technologies available to improve fishing outcomes. Whilst e-logistics technologies have seen significant development over the years, into the fourth industrial revolution, the fishing industry has been slow in adopting and using these available technologies. Furthermore, there is limited research into adoption influencing factors within the fishing industry in the Western Cape. As such, e-logistics technology adoption across numerous industries in multiple countries was investigated, enabling the realisation of the first objective and the development of the second objective.

5.2.2 Objective 2: To identify conceptual frameworks that provide a lens to investigate e-logistics technology adoption in the fishing industry in the Western Cape.

The second objective was achieved through a literature review of available technology adoption frameworks across numerous industries. The literature review emphasised the concepts of e-logistics technology adoption and data analytics, the Western Cape fishing industry supply chain and other fishing industry trends related to technology development, adoption and use. The technology adoption frameworks' feasibility was assessed and both pros and cons were detailed. The development of the conceptual framework for the research was logically explained based on the analysis of numerous technology adoption models, frameworks and studies. These steps are outlined in Section 2.6 and the subsequent subsections. A major highlight was the availability of numerous technology adoption frameworks discussed in the section and the objectivity of each framework in responding to the research question: *"What are the primary factors influencing the adoption of e-logistics technology in Western Cape fishing organisations?"*. The selected TOE-DOI framework was adopted as it captured the research questions and objectives more comprehensively compared to alternative frameworks. Furthermore, the design of each framework, TOE and DOI, complements the other, enabling a more balanced analysis of influencing adoption factors.

5.2.3 Objective 3: To use the identified conceptual technology adoption framework to design a suitable research instrument to inform research activities.

The literature review additionally informed the design of the research instrument. Steps taken to develop the research instrument and all research methodology activities are detailed in Chapter 3 and its subsections. A combination TOE-DOI conceptual model was used in the development of a combination of online survey and interview research instrument. Both the online survey and the interview questions are provided in Appendices A and B, respectively, summarising the journey to achieving the third objective. The two instruments were used in tandem to quantify respondents' perspectives on the most influential adoption factors and to qualify those following the analysis of the qualitative responses from the interviews. The online survey was emailed to prospective respondents before the interviews, with clarity of the ethical standards upheld, the definitions of the major technology concepts and all communication avenues and consent logistics. The Ethical Clearance, Introductory Letter and Introductory Email are included in Appendices C, D and E, respectively. Appendix E is the template that was customised to fit into the various email introduction needs.

5.2.4 Objective 4: To identify factors that affect e-logistics technology adoption.

The fourth objective was achieved through the analysis of both the online rank and interview responses. Chapter 4 details the achievement of this objective, providing the online survey rank outcomes and qualitative analysis of the interview responses, including verbatim responses where necessary. In identifying factors that affect e-logistics technology adoption, primary factors were separated from other secondary or non-influential factors. Both past realities and future logical perspectives informed the respondents' responses, with organisations using modern e-logistics technologies considering what their experience revealed. In contrast, those using older technologies or a combination of old and new technologies considered what their transition might look like in future. Constructs of *Technology, Organisation* and *External Environment*-related factors were identified as influencing an organisation's technology adoption plans and executions. While the fishing industry showed some similarities with other industries in technology adoption influencing factors, there were unique factors identified and discussed in Chapter 4 and Section 5.3.

5.2.5 Objective 5: To develop a framework to support the adoption and implementation of data analytics enabling e-logistics technologies in the Western Cape fishing industry.

The fifth objective was achieved and the achievement thereof is discussed in the next section, Section 5.3. The framework for adopting data analytics enabling e-logistics technologies considers primary adoption factors identified, discussed, and analysed, and the relationships between the factors and the stakeholders. As a key point of note, the framework presents the primary factors only considered to have the most influence in the adoption decision of any Western Cape fishing organisation.

5.3 Western Cape Fishing Industry's e-Logistics Technology Adoption Proposed Model

In Chapter 4:, using the TOE-DOI model, the three constructs of *Technology*, *Organisation* and *Environment* contained concepts relevant to the Western Cape fishing industry. The three constructs were found to be primary factors of adoption. Within these constructs, however, some concepts informing the constructs were not found to primarily influence the decision to adopt e-logistics technologies.

The identified primary adoption factors occur within an interdependent environment which recognises one element as an enabler of the other, with continued collaborations and continued innovation being necessary concepts to realise the value of the adopted technologies. The relationships between primary e-logistics technologies adoption factors must be noted.

Additionally, both the technology and the reality of technology users were emphasised and adoption factors were seen as relevant from either perspective. It must be noted that continued partnerships enable continual innovation by incorporating various inputs from the different stakeholders at each technology adoption factor. For the Western Cape Fishing Industry, e-logistics technology adoption can be improved as these partnerships are nurtured, maintained and improved.

Furthermore, in South Africa, in the nation's plight towards the correction of past realities relating to various groups and classes of people, ethical realities of development and policy were highlighted as influencing the types of technology to adopt. As such, while perceptions play a role in the decision to adopt a technology, policy augments the influence towards such a decision. These primary influencing factors of technology adoption are illustrated in Figure 30 and further discussed in the sections that follow.

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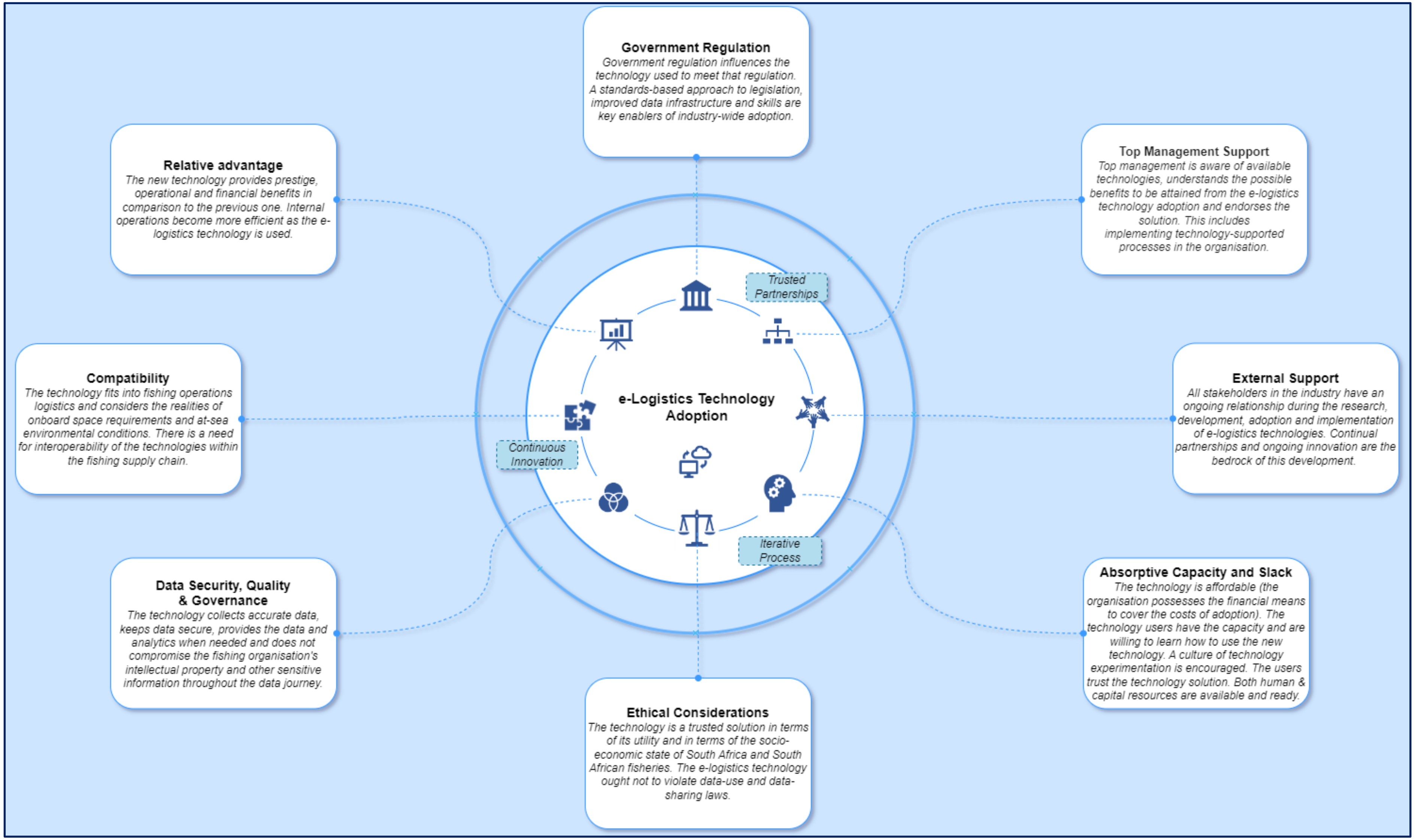

Figure 30: Western Cape Fishing Industry e-Logistics Technologies Adoption Model

This research acknowledges the reality of the fishing industry dynamics and proposes a model for technology adoption in Figure 30 informed by the prevailing industry realities. South African fisheries, especially small-scale fishers are among fisheries considered data-scarce. E-logistics technologies have the potential to reduce this scarcity. The research presents e-logistics technology adoption factors as considered by various stakeholders in the industry, from their respective perspectives. The fishing organisation in its bid towards profitability and data analytics improvements uses various means and technologies to manage operations. The technology organisation identifies opportunities and develops solutions to aid the fishing operations organisation. At the same time, fishing operations organisations form associations to build industry partnerships which in turn aid the development of operations. Furthermore, governments provide legislative measures within which to carry out operations. These include quota management, protection of marine species and other sustainability measures. To enable efficient management and monitoring of interventions, fisheries scientists are needed, and fisheries science and other data analytics are thus used to inform policies further. E-logistics technologies enable the data capture, storage, analytics and sharing of the data across this supply chain. The data requirements and analytics are inter-connected and the more in sync these are between the data user and the technology developer, the greater the innovation. Continuous innovation allows for operational efficiency improvements, including improved reporting and monitoring which in turn allow for increased revenue or reduced cost and improved profitability. This allows for continual investment in the business, in people, in government, in science and the industry enabling fisheries sustainability. An all-stakeholder-inclusive fishing industry builds trust amongst supply chain partners, ensures that technology continues to be relevant, and enables efficient fishing processes, resulting in material returns that in turn allow for further investments into fisheries sustainability and community development.

5.3.1 Technology Construct

Of the adoption factors investigated within the *Technology* construct, concepts of *complexity, trialability* and *observability* were not found to be primary drivers of technology adoption. While *trialability* and *observability* were found to influence technology adoption in numerous studies (Kumar et al., 2018; Vanclay, 1992), including in farming research, in this research, respondents emphasised a partnership that involves all stakeholders from the development of technology to the adoption and implementation thereof as opposed to isolated instances of trials and partnerships. In this industry, fishing organisations drive efficiency of operations and therefore prefer to be part of the technology solutions' development, thus the partnership emphasis.

Within this construct, therefore, concepts of *relative advantage* and *compatibility* were identified as primary driving factors of adoption. Technologies that show utility in terms of improving the fishing processes outcomes, improving the sustainability of fishing, improving the organisation's economics while capturing fishing logistics and addressing the realities of at-sea and onboard conditions are more likely to be adopted. There is a drive towards the internet of everything and thus the need for technologies that allow for interoperability onshore and offshore, onboard and at the analysis site, incorporating IoT, IoD, IoS and IoP as discussed in Section 2.3 and 2.4.

5.3.2 Organisation Construct

Within the *Organisation* construct, the *size of the organisation* concept was not found to be a primary driver of e-logistics technology adoption. *Top management support* and *absorptive capacity and slack* were found to be primary drivers of adoption. Top management can ensure that relevant resources are strategically made available and enforce operational measures towards the required technology adoption. Furthermore, data literate management may influence the organisation towards e-logistics technologies that improve data analytics. While the research showed this to be a driving factor, it must be accompanied by *absorptive capacity and slack*. The availability of resources, both financial and human, was seen to drive e-logistics technology adoption. Human capital must be willing and able to incorporate e-logistics technologies for these to work efficiently within the business. Supporting these factors is the affordability of the technology. While on the one end, the availability of financial flexibility influences the adoption, on the other hand, affordability of the technology influences the decision of whether to adopt or not adopt the e-logistics technology. The decision, therefore, of whether or not to adopt e-logistics technologies would be influenced primarily by these factors and less by the size of the organisation.

5.3.3 Environment Construct

Competitive pressure was not found to be a primary influencing factor within the *Environment* construct. In contrast, *external support* and *government legislation* were found to be primary *external environment* factors of e-logistics technologies adoption. There is an ongoing need for continual and trusted partnerships between all stakeholders. As partnerships are strengthened, opportunities for stakeholders to understand each other's perspectives and wholly understand their value chain are presented. This enables the alignment of technology, regulations and fishing organisations' operations processes, encouraging the adoption of e-logistics technologies in the management of fisheries industry-wide. This finding supports Seuring & Müller's (2008) conclusion that there is an increased need for cooperation among partner stakeholders to ensure sustainable supply chain management. The authors (ibid) suggest a triple-bottom-line management approach where social and environmental issues are considered together with financial issues in managing a supply chain. The emphasis on partnerships by respondents thus suggests a downstream improvement of analysis as the upstream data collection is improved through the adoption of e-logistics technologies across the value chain. These partnerships can potentially mitigate adoption issues due to a failure to meet users' requirements, an issue identified by Bernroider (2008) and Jokonya et al. (2014) as endemic across industries. Furthermore, the partnerships enable interoperability, enabling IoD, IoP, IoS and IoT in the fishing industry.

In the same vein, it is also worth noting that, in enabling partnerships, a genuinely democratic process is not necessary. Instead, as shown in section 4.6.3.4 and suggested by Southern (2017), only a representative group of the larger industry is needed for technology development, while adoption into the entire industry may be driven both by the utility of the technology and by the regulation of the government. The strengthened partnerships thus have the potential to improve e-logistics technologies' research and development, further enabling the adoption thereof. The partnerships ought to include as many stakeholders as possible, with a key consideration on the government, technology developers and vendors, fishing associations and fishing operations organisations.

Government regulation was also seen to drive technology adoption, albeit with different influence levels from organisation to organisation. A major highlight provided by the respondents was that organisation-wide adoption of e-logistics technologies tends to be internally driven, within organisations, with the objective being improved efficiency. However, for industry-wide e-logistics technologies adoption, government regulation is a major player as the government may enforce policy and procedures, regardless of whether or not the efficiency improvements are known or met. Furthermore, a standard-based approach to government legislation was seen as more flexible for innovation. In this manner, therefore, government regulation was seen as influencing technology adoption with opportunities for the South African fishing industry to develop and enforce better regulations.

By the same token, government regulation relating to quota management, fishing rights and social justice initiatives like affirmative action influence investment into the industry, including the choice of technologies adopted. Uncertainty in government regulation may militate against the adoption of e-logistics technologies as it creates an environment of uncertainty. The government, as part of the external environment, ought to thus consider these realities and positively influence e-logistics technology adoption by enabling a sustainable, fair fishing environment. A more predictable environment positively influences investment into the industry, and thus a possible investment into longer-term beneficial e-logistics technologies while the opposite may discourage this development.

5.3.4 Data Quality, Security and Ethics

Very much related to the efficiency-driven nature of fisheries operations, data quality, data security and ethical considerations were identified as influencing e-logistics technology adoption in the Western Cape fishing industry. Data quality as it relates to the accuracy of the data collected and the timeliness of the analysis possible was emphasised by respondents. It is worth noting that, e-logistics technologies like electronic logbooks can collect data with minimal vessel skipper/ captain effort and thus allow the onboard team to focus on their primary objective of catching fish while at sea. At the same time, these IoT possibilities allow various software to read data from vessel sensors in real-time and provide feedback to the vessel crew accordingly, including the ability to share the data and analyse at close to real-time as possible. Technologies that operate similarly at affordable levels, improving operational efficiency, are more likely to be adopted.

Furthermore, data security was seen as driving the decision to adopt an e-logistics technology. Data security as a primary influencing factor includes compliance with personal data laws, controlled data access, limited data manipulation possibilities, protection of fishing grounds data and intellectual property, and protection from hacking and viruses. While in some organisations, data security was an assumed capability of e-logistics technologies, an overarching realisation was that any breach of the security measures would be a definite forfeit or exclusion of the e-logistics solution from the organisations' suite of solutions.

Ethical considerations were also identified as driving the decision to adopt an e-logistics technology. In South Africa, the gap between the richest and poorest was amongst the highest globally according to the Gini Coefficient measure of 0.65 in 2015 (Leibbrandt & Díaz Pabón, 2021). Unemployment rates have persistently remained high, at 34.5% as of 2022 (Stats SA, 2022). As such, employment opportunities and losses drive decisions relating to technology adoption. E-logistics technologies that may result in perceived unsustainable job losses are less preferred to those that support increased efficiency and growing employment prospects due to organisations and industry growth.

5.4 Evaluation of the Research

Reliability and validity of research consider elements of credibility, transferability, dependability and research confirmability (Armour & Williams, 2022; Babbie, 2014). (Armour & Williams, 2022) define credibility as considering how results reflect the reality of participants. Credibility concerns truth-value (Korstjens & Moser, 2018; Lincoln & Guba, 1985). Further definitions are discussed in Section 3.9. In this research, credibility was maintained through an online rank instrument which was used as a complement to the interview instrument to enable a quantitative rank of factors of adoption and to enable respondents to quantify their responses online and qualify them during interviews. Definitions of the major terms and constructs, including the definition of e-logistics technologies, in the research were provided beforehand to prospective respondents via email and further provided during the interviews where such a request was made. A comprehensive literature review was undertaken, and concise descriptions of the methodology used in data collection and analysis are provided. Chapter 3: details the research methodology and Chapter 4: details the analysis findings and discusses these, including the verbatim statements of the respondents. Interview responses were recorded, save for one interview, and recordings were transcribed. All respondents who consented to have interviews also consented to their responses being analysed and this research includes all interviews analysis. Furthermore, definitions of constructs investigated, identified or realised were all documented and included as part of the research findings.

Armour & Williams (2022) define transferability as providing sufficient details to show the context in which the research occurred. As noted by Korstjens & Moser (2018), the reader and not the researcher make the transferability judgement. However, in enabling transferability of findings, Chapter 3: details the research methodology, providing definitions of the unit of analysis, and the organisation, describing the research population and providing all steps taken during the data collection phase of the research and the analysis thereof. The content and analysis of responses are contextualised by providing the type of role and type of organisation the respondent operates. A summary of respondents is provided in Table 3 and includes their respective tenure at the fishing organisation and involvement within the fishing industry, regardless of their employing organisation.

Armour & Williams (2022) further define dependability as being concerned with the repeatability of the results. Dependability includes consistency, considering whether the analysis has followed acceptable standards for a particular research design (Korstjens & Moser, 2018; Lincoln & Guba, 1985). This research protected dependability by ensuring that all interviews were transcribed, and online survey results were preserved. Post the transcribing of interviews, coding occurred. The process of coding is described in Chapter 3.8 and Figure 7. The qualitative nature of the research adopted an interpretivism research paradigm, further informing the survey research instrument design and the purposive sampling approach to identifying prospective interview respondents. The literature review in Chapter 2: also provided a lens into best practices in qualitative research, as is the nature of this research. Therefore, research standards shown and discussed by (Armour & Williams, 2022; Babbie, 2014; Creswell, 2014; Rossman & Rallis, 2012; Babbie, 2010; Babbie & Mouton, 2001) amongst numerous literature were upheld.

Confirmability is one element only satisfied once all other elements of credibility, transferability and dependability have been satisfied (Armour & Williams, 2022). As noted by Rossman & Rallis (2012) and Katunga (2019), in qualitative research, ultimate reliability may not always be possible due to the nature of the research, which focuses on people and their unique texts and behaviours. However, all identified steps discussed were taken to mitigate any biases in data collection and analysis. Furthermore, the diverse backgrounds of the survey respondents acted as complementary inputs to mitigate bias in the research findings. In particular, personnel within their organisations ranged from fishermen to analysts and executives to technology developers, providers and consultants involved in the fishing industry. The organisations also varied in operations with fishing consultancies, fishing technology development organisations, fishing associations and fishing operations organisations, all being included as part of the population of the study. The groupings of both organisations and role types are provided in Figure 8, Figure 9 and Table 3. The research findings were compared to other adoption studies and recorded accordingly in Chapter 4, following a theoretical triangulation approach.

The interview questions followed a structural flow from one construct to another, allowing respondents to respond coherently to questions while enabling a structured analysis approach described in Chapter 3.8. Furthermore, the interview transcripts were continually referenced and juxtaposed against the research question during the analysis phase of the research. Codes were re-visited on multiple occasions and the data analysis process was iterative, with continual adjustments to constructs as more understanding was realised. The findings were additionally compared to other similar research.

5.5 Contribution of Research

This research contributes to the technology adoption body of knowledge, particularly on South Africa and the Western Cape fishing industry. While the research was carried out within a limited geographic area, results may be extended to broader geographic areas, considering a similar setting to the research described in Chapter 2 and Chapter 3.

The research additionally contributes to the United Nations Goals; SDG9 by encouraging innovation and advocating for avenues available to improve e-logistics technologies in the fishing industry. It also supports SDG14 by providing a lens into more efficient information management opportunities.

The research provides insightful constructs and relationships between different stakeholders in the fishing industry and how available technologies, adopted technologies, legislation and other socio-economic factors interplay. Benefits to different stakeholders are summarised in Section 5.5.1 to Section 5.5.4.

5.5.1 *Fishing Operations Organisation*

The research creates an awareness of technological solutions that complement other fisheries management activities. The e-logistics technologies are discussed concerning global fisheries challenges. The research further provides a lens into how e-logistics technology adoption may be improved to enhance fishing operations by providing a framework that operations organisations may consider improving their business.

5.5.2 *Fishing Association and Consultancies*

The research further provides awareness to the government and fishing associations on how industry-wide changes may be made to enable e-logistics technology adoption. The adoption, while at the centre of the research, is accompanied by the benefits associated with such adoption, enabling an objective analysis of fishing associations and consultancies into where technology interventions may be taken to improve the fishing industry. In particular, the research provides e-logistics technology adoption factors that associations and consultancies may develop towards improved data analytics industry-wide.

5.5.3 *Fishing Technology Organisation (Vendor)*

From a business development perspective, the e-logistics adoption framework allows fishing technology companies to develop their solutions and systems around the fishers' perspectives and expectations. This is imperative as it bridges the gap between humans and technology, encouraging the possibilities of human-centred innovations. The research emphasises technology aspects that fishers find to be providing the greatest utility in their fishing endeavours, thus presenting areas that could be exploited further to enhance the organisations' material outcomes.

5.5.4 *Government*

The research further provides awareness to the government on how industry-wide changes may be made to enable e-logistics technology adoption. The framework identifies the role of the government as a primary influencing factor of e-logistics technology adoption, highlighting areas of attention in fisheries legislature and expectations related to those. Fish is a natural resource and tends to require some form of regulatory mandate to control or monitor, with industry growth and continuity, environment sustainability, prevention of illegal fishing and habitat protection as features within fisheries management (Fujita, et al., 2018). Providing factors that influence e-logistics technologies that improve the development, enforcement, control and monitoring serves all stakeholder interests by enabling sustainable, profitable and equitable fishing, enabling economic returns to the government and all other stakeholders. E-logistics technologies adoption provides an opportunity for improved data analytics and therefore improved management and sustainability of the industry, improving the state of South African fisheries.

5.6 Limitations of the Study

The research was limited to the Western Cape fishing industry. However, while this is a limited geographic area, the research in the Western Cape provides a foundation for understanding e-logistics technologies' adoption within the South African fishing industry context and in similar nations. The Western Cape has the most fishing activity in South Africa, and thus, most of the fishing companies (FishSA, 2019). It is a majority fish industry contributor to the South African economy in terms of both Gross Domestic Product from fisheries and employment (Brick & Hasson, 2020).

The population surveyed, although diverse, was relatively small compared to other studies, given the limited scope of a mini-thesis. In this light, therefore, interpretations of the study outcomes must keep in mind the population of the fishing industry and the sample size recorded as part of this research accordingly. While this featured as a limitation, it must be noted as well that considerable steps were taken to mitigate this reality. Chapter 3: and 5.4 discuss the methodology and evaluation of the research, respectively.

Furthermore, the fishing industry has numerous dynamics that include wild fisheries commercial capture, fish farming, small-scale fishing, larger-scale fishing, aquaculture and the various types of fisheries and fishing methods. Technology adoption as it relates to these dynamics was not analysed, yet the findings provide a sound foundation on which to base further fisheries-specific research.

5.7 Recommendation for Future Research

The adoption of technologies is but one component of technology use and benefit within a wider ecosystem of the Internet of Things, the Internet of People, the Internet of Data and the

Internet of Services. The adoption, therefore, does not imply that data will be used for management (Fujita, et al., 2018), nor does it imply the optimal use and benefit from the use of the adopted and utilised technology. There is a need to further the study into the continued use of e-logistics technologies for enabling data analytics and benefits realisation related to both adoption and continued use. Further studies may include awareness evaluations, businesses' propensity to innovate and adopt new technologies and the continued use of e-logistics technologies.

Data availability from e-logistics technologies may not guarantee the data quality and integrity necessary for effective fisheries management. This necessitates further research into user acceptance (Taherdoost, 2019) and the continued utility of available technologies in supporting data analytics.

Future research may include security-related elements. In particular, data security may relate to security in terms of the technology being secure from unwanted access or corruption, data confidentiality and data integrity. Data security may be separated from the Protection of Personal Information Act (POPIA), a compliance component. At the same time, it may also relate to organisations' Intellectual Property and other security or protection-related elements. The different protection and security elements may be investigated regarding how they relate to technology adoption.

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Appendices

Appendix A: Research Instrument – pre-Interview Online Survey

Page/ Section	Group	Details
Page 1	**Introduction Letter and Consent**	See Appendix D
Page 2	**Respondents' Demographics –** *Please provide the below information*	Name
		Surname
		Email
		Gender
		Company
		Yrs of Exp in the Fishing Industry
		Yrs of Exp in current company
		Current Role
Page 3	**Technology Construct –** *Please consider the statements below and rank them in terms of importance from the highest importance (1) to those of the lowest importance (6). Each rank can only be chosen once (e.g. 1 can only be selected once, 2 can only be selected once etc.)*	The adoption of technology will improve the standing of my company in the sector.
		The extent to which new technology is compatible with our existing IT systems and processes.
		The degree to which the technology is perceived as being complex.
		The extent to which new technology may be experimented with or adopted incrementally or cancelled altogether.
		The degree to which the successes of the new technology are visible to the company.
		The extent to which security (data security, company information security) of the new technology is the primary driver of the decision to adopt a technology.

Page/ Section	Group	Details
Page 4	**Organisation Construct –** *Please consider the statements below and rank them in terms of importance from the highest importance (1) to those of the lowest importance (4). Each rank can only be chosen once (e.g. 1 can only be selected once, 2 can only be selected once etc.)*	The extent to which top management support of new technology is the primary decision driver of whether we will adopt the new technology or not.
		The extent to which the size of our organisation (both revenue and the number of employees) is the primary decision driver of what technology we adopt and use as an organisation.
		The degree to which the human resources skills (fishermen and other users of technology) determine the technology to be adopted. When technology is familiar, there is an increased likelihood that we will adopt it.
		The degree to which the new technology supports our strategy as an organisation is the primary decision driver of whether we adopt the new technology or not.
Page 5	**External Environment Construct –** *Please consider the statements below and rank them in terms of importance from the highest importance (1) to those of the lowest importance (3). Each rank can only be chosen once (e.g. 1 can only be selected once, 2 can only be selected once etc.)*	The extent to which pressure from competitors can be combatted by the adoption of the e-logistics technology.
		The extent to which external support e.g. software vendor availability and contactability and efficiency are primary drivers in adopting new technology.
		The degree to which government regulation is a primary driver in our decision of which technologies to adopt.
Page 6	**Ranks of Major Constructs –** *Please consider the statements below and rank them in terms of importance from the highest importance (1) to those of the lowest importance (3). Each rank can only be chosen once (e.g. 1 can only be selected once, 2 can only be selected once etc.)*	The extent to which the nature of the new e-logistics technology drives our decision to adopt and use the technology.
		The extent to which the available resources (human, financial, capital) drive our decision to adopt and use e-logistics technologies.
		The extent to which the external environment (competition, government, software support services) drives our decision to adopt and use e-logistics technologies.
	Any other Comment	

Appendix B: Research Instrument - Interviews

TECHNOLOGY – ***Construct T of the TOE Framework***		
Construct	**Objective**	**Questions**
Relative Advantage	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess whether a non-Adopted company is considering Relative Advantage as part of their potential adoption.	a) How important is your position in the industry?
		b) If an e-logistics technology will give you an advantage (prestige, economic, productivity) - will that on its own convince you to buy the technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the extent to which Relative Advantage influenced the decision to adopt;	a) When you adopted e-logistics did you consider how it would place you at an advantage in the industry, in terms of prestige or economic or productivity?
		b) To what extent did this industry advantage feature in your decision to procure the e-logistics technology?
Security	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the degree to which security, data security and governance influence the decision to adopt a technology.	a) Data security and governance are buzzwords in the data industry. In your organisation, does an understanding and assurance of data security in technology primarily drive the decision of whether a new tech will be adopted or not?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the degree to which security, data security and governance influenced the decision to adopt a technology.	a) As you were deciding on whether or not to adopt new e-logistics technologies, to what extent was the concept of security (data protection and security etc) a major driver of the decided outcome?
Compatibility	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the relevance of specific e-logistics technologies (e.g. e-logs, GPS, iEMR etc) in relation to business processes and systems.	a) How important is compatibility between business processes/ available business systems and the new e-logistics technology?
	b) To assess the extent to which compatibility of new e-logistics technologies to business processes and systems influences the decision to adopt.	b) Would you consider this compatibility as a primary driver of the decision to adopt new e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the extent to which compatibility of adopted technology with previous processes influenced the decision to adopt.	To what degree what the compatibility of the new technology to your business systems and processes a priority decision-maker in adopting e-logistics technologies?

Construct	Objective	New Questions
Complexity	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the degree to which perception and or knowledge of ease of use of available technology on its own, by company personnel changes the decision to adopt.	a) To what extent does the complexity or the simplicity (ease) of use of a technology influence your decision to adopt the e-logistics technology?
		b) Regardless of other known benefits of a particular technology, would complexity alone influence your decision to adopt/ not adopt the e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the degree to which ease of use or perception of ease of use of adopted technology within the company influenced the decision to adopt.	a) To what extent was the perceived complexity of the technology (or simplicity), the primary driver of the decision to adopt e-logistics technologies?
Trialability	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess whether trialability is an important factor for the company in deciding to adopt an e-logistics technology and to what degree this is so.	a) In your decision to adopt a technology, does the ability to easily implement incremental milestones and or stop the technology altogether influence to a great extent whether you adopt the technology or not?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess whether the adopted technology was easily piloted and whether that ability/ inability was a factor in the decision to adopt.	a) To what degree was the possibility of easily piloting or trialling the software the key driver of the decision to adopt the said technology?
Observability	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the extent to which observed benefits of technology experienced by other companies influence the decision to adopt.	a) Does the organisation benchmark any technology likely to be adopted against seen benefits from other companies
		b) If yes, does the observed success in one company automatically imply a decision to adopt an e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess whether the adopted technology decision was influenced by observed benefits in other companies.	a) To what extent would you consider the observed results in another company using the new e-logistics technology a primary influence in the adoption of the technology?
		b) If no organisation was observed, then would you say the idea of seeing positive results from technology in another company can be a key driver of the decision to adopt the e-logistics technology?

ORGANISATION – *Construct O of the TOE Framework*		
Construct	**Objective**	**New Questions**
Top Management Support	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess top management's awareness of technology and the degree to which they influence the decision to adopt.	a) To what degree do you consider top management's endorsement and support of technology as being a primary driver to adopt an e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the degree to which top management awareness and support of adopted technology influenced the decision to adopt.	a) To what extent did you find the role of top management and their support in deciding the new e-logistics technology to adopt? Was this a primary feature?
Size	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the extent to which organisation size (employee count and size of operations) affects the decision to adopt a technology.	a) To what extent is the size of your organisation influencing the decision of whether to adopt e-logistics technologies for data analytics or not? Please consider size in terms of employee numbers, the size of your operations, annual revenue and industry market share.
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the degree to which the size of the company and the size of the operations influenced e-logistics technology adoption in the past.	a) To what extent was the size of your organisation a major driver of the decision of whether to adopt e-logistics technologies for data analytics or not? Please consider size in terms of employee numbers, the size of your operations, annual revenue and industry market share.
Slack (Absorptive Capacity)	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the extent to which the availability of funds, people, people skills, and information technology infrastructure (uncommitted resources) influence the decision to adopt e-logistics technologies.	a) To what extent within the organisation does the education of the people, the availability of IT resources and the availability of funds influence a decision of whether to adopt an e-logistics technology?
		b) Would you consider the availability of these factors as a major driver in your decision to adopt and would these alone make you decide on adopting a new e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To evaluate whether the availability of uncommitted resources influenced the decision to adopt, on its own.	a) To what extent within the organisation did the education of the people including fishermen, the availability of IT resources and the availability of funds influence the decision of whether to adopt the new e-logistics technology?
		b) Would you consider these factors as a major driver in your decision to adopt new technology and would you say these alone could have been the sole/ primary drivers of your e-logistics technology adoption decision?

External Environment – *Construct E of the TOE Framework*		
Construct	**Objective**	**New Questions**
Competitive Pressure	**Non-Adopted Company**	**Non-Adopted Company**
	a) To understand and assess the extent to which competitors influence informing the company's e-logistics technologies adoption.	a) The decision to adopt any technology is driven primarily by that the industry is very competitive and perhaps the technology may give a competitive edge. Some competitors are already using this technology. To what extent is this statement true in your experience and to what extent does this reality influence your decision to adopt an e-logistics technology?
	b) To assess the extent to which industry competition intensity (push and pull factors) influences the decision to adopt.	
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the extent to which competitors influenced the decision to adopt e-logistics technologies.	a) The decision to adopt any technology is driven primarily by that the industry is very competitive and perhaps the technology may give a competitive edge. Some competitors are already using this technology. To what extent was this statement true in your experience and to what extent did that reality influence your decision to adopt the e-logistics technologies in use?
	b) To assess whether competition intensity, in the fishing industry influenced the decision to adopt.	
External Support	**Non-Adopted Company**	**Non-Adopted Company**
	a) To assess the extent to which third parties, vendors or software providers influence the adoption of e-logistics technologies within the business.	a) To what extent do you consider external support from software vendors and other service providers to be a primary influencing factor for whether to adopt an e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the extent to which third parties, vendors or software providers influenced the adoption of e-logistics technologies within the business.	a) With regards to your adopted e-logistics technologies, to what degree were the availability of software vendors and support thereof a major driver in making your decision?
Government Regulation	**Non-Adopted Company**	**Non-Adopted Company**
	a) To evaluate the influence that government regulation and laws have in the decision to adopt different e-logistics technologies.	a) In South Africa, some fisheries are closely regulated by the government. Do government legislature and laws feature in your determination of what technologies to consider for your data analytics? - And to what extent would you say this is a factor in your decision to adopt an e-logistics technology?
	Tech-Adopted Company	**Tech-Adopted Company**
	a) To assess the extent to which government regulation and legislation influenced e-logistics technology adoption.	a) In South Africa, some fisheries are closely regulated by the government. Do government legislature and laws feature in your determination of what technologies to consider for your data analytics? - And to what extent would you say this was a factor in your decision to adopt an e-logistics technology?

Appendix C: Ethical Clearance

UNIVERSITY *of the* WESTERN CAPE

60 YEARS *of hope, action & knowledge*

22 July 2021

Mr B Khumalo
Information Systems
Faculty of Economic and Management Sciences

HSSREC Reference Number:	HS21/5/40
Project Title:	A conceptual framework for the adoption of e-logistics technologies: Towards improved data analytics practice in the Western Cape fishing industry.
Approval Period:	21 July 2021 – 21 July 2024

I hereby certify that the Humanities and Social Science Research Ethics Committee of the University of the Western Cape approved the methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report by 30 November each year for the duration of the project.

The permission to conduct the study must be submitted to HSSREC for record keeping purposes.

The Committee must be informed of any serious adverse events and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Director: Research Development
University of the Western Cape
Private Bag X 17
Bellville 7535
Republic of South Africa
Tel: +27 21 959 4111
Email: research-ethics@uwc.ac.za

NHREC Registration Number: HSSREC-130416-049

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix D: Introduction and Definitions Letter

Faculty of Economic and Management Sciences
Department of Information Systems
Information Systems Research Project : e-logistics technology adoption within the Western Cape fishing industry

A conceptual framework for the adoption of e-logistics technologies: Towards improved data analytics practice in the Western Cape fishing industry

I am Bradley Bucky Khumalo, a student at the University of the Western Cape (South Africa) pursuing a Masters' Degree in Information Management. I am conducting a study to investigate factors that influence the adoption of e-logistics technologies which help facilitate data analytics in Western Cape fishing companies. This study is solely for academic purposes and is in partial completion of my degree. The study will complement other fisheries sustainability studies by providing a conceptual framework for the adoption of e-logistics technology in the Western Cape fishing industry.

Examples of e-logistics technologies
Paper to Digital Technologies, electronic logbooks, sensors (weather, water conditions etc.), VMS and other Satellite Communication Technologies, smartphones, high-resolution cameras, Internet of Things and other Cloud Devices and Systems including Cloud-based Data Storage Systems and traceability technologies

What will I be asked to do if I agree to participate on this online survey?
If you agree to participate in this research project, you will be asked to respond to a number of single choice questions. The online survey should take approximately 10 minutes. A further 40 minutes interview will be requested and where accepted, will form part of the research. If you do not wish to respond to the online survey or interview or both, you do not have to.

Would my participation in this study be kept confidential?
You are not required to provide any personal details, such as your name, address or identity number, although you may optionally provide your name. All other details such as your age, education, employment status are therefore anonymous and where the name is shared will remain confidential and will not be shared.

What are the risks of this research?
There are no known risks associated with participating in this research process. This research will not expose you or your company to any harm as a result of your participation.

What are the benefits of this research?
The outcomes of this study will serve to inform organisations about important factors to consider with regards to adopting e-logistics technologies through the development of a conceptual framework as such.

Do I have to be in this research and may I stop participating at any time?

Page 1 of 2

Your participation in this survey is completely and entirely voluntary. You may choose not to take part at all. If you decide to participate in this survey, you may stop participating at any time.

What if I have questions?
If you have any questions feel free to contact the study leader:

Contact details of project leader (study supervisor)
Name: Shaun Pather
University: University of the Western Cape, Department of Information Systems
Telephone:0219593248
Email: spather@uwc.ac.za

Contact details of student
Name: Bradley Bucky Khumalo
University: University of the Western Cape, Department of Information Systems
Telephone: 0817902603
Email: 3716198@myuwc.ac.za

NOTE: This research project has received ethical approval from the Humanities & Social Sciences Research Ethics Committee of the University of the Western Cape, Tel. 021 959 2988, email: research-ethics@uwc.ac.za

Page 2 of 2

Appendix E: Introduction Email Template

Good Day,

I am Bradley Bucky Khumalo, a Masters' Student studying at the University of the Western Cape, in South Africa.

As part of my studies at UWC, I am conducting Information Systems and Management research and request an opportunity to interview with your organisation (anyone involved in IT and IT adoption) relating to the adoption and use of fishing technologies towards the enabling of data analytics. My research is primarily focusing on the Western Cape fishing industry, in South Africa.

I am available on both email and mobile phone as per the details provided. I have attached:

- My Research Introduction and Request to Conduct an Interview
- My Ethics clearance from the University of the Western Cape.

Should you be happy for me to conduct this interview, I can liaise with you for an opportune time to carry out the interview. In the meantime, I have provided a link to an accompanying online survey ranking plausible adoption factors from most important to least important: *link to the survey provided*.

I look forward to your positive response.

Kind Regards,
Bradley Bucky Khumalo
Contact details provided