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# The Role of Big Data Analytics Capability in Improving Sustainability in the Logistics Sector in Oman

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**Abstract:** Oman's logistics scene is growing fast, driven by goals like Oman Vision 2040 and a plan to hit Net-Zero emissions by 2050. Because of this quick growth, keeping things sustainable isn't just a rule; it's super important. Big Data Analytics is known to boost supply chain speed and success. It hasn't gotten much attention for helping logistics be sustainable, especially in countries still working on their economy. A lot of research looks at Big Data stuff separately, like the tech, how it's handled, and the people using it. This research doesn't explain how everything fits together *to* affect the economy, society, and the environment. So, we don't fully understand how Big Data Analytics and sustainability work together in logistics. This study looks at this. It uses a framework that combines a few ideas: how resources help, how things change, tech, organizations, environment and a tech acceptance model. Through interviews with 25 managers in Oman's logistics companies, the study looks at how different abilities work together to improve sustainability. The study shows that Big Data Analytics lets companies spot new chances, stay competitive, and change how they use resources when faced with environmental concerns. By getting info from a country that's still growing, the study backs up what others say about Big Data Analytics and sustainability. It also gives tips to leaders in business and government who want to use data to push for sustainability in similar markets.

**KEYWORDS:** sustainable logistics, big data analytics, big data analytics capability, resource-based view, dynamic capability view, triple bottom line (TBL).

## I. INTRODUCTION

In the last 20 years or so, we've seen a crazy explosion in the amount of data created every day, both in our personal lives and at work. This is mostly because everyone's using digital stuff all the time for fun, to chat, and to make things run smoother at work [1, 2]. Companies handle tons of different info, like user activity, what customers buy, and stuff people post online. Because data is so big and important, big data analytics (BDA) has turned into a must-have for businesses [3]. People are getting more and more interested in BDA, both in studies and in the real world, and it's expected to keep getting bigger. Still, there's no clear way to handle all this data to get useful insights [4]. That's why Big Data Analytics Capability (BDAC) was created it means being able to pull useful stuff out of big data [5].

BDA can turn data into useful business info, which helps make better choices and boosts how well a company does. However, even if big data has a lot to offer, how much it helps depends on whether a business can collect, store, and process all the huge amounts of data that come from real life and models [6]. Good logistics is super important for companies to grow and be environmentally responsible [7]. Using big data analytics in logistics has been a game-changer, helping companies run better, waste less, and be kinder to

the planet [8]. Logistics helps with sustainability by planning smarter routes, cutting down on emissions, and supporting general transport [9]. How good a country's logistics are is still a big deal for its economy and how well it trades with other countries. But even with all this progress, there's not a lot of research out there on how big data analytics links innovation with the three parts of sustainability in companies, especially when you mix big data analytics and logistics [10-13].

## *1. PROBLEM STATEMENT*

All over the world, the logistics industry has big problems with sustainability. It uses a lot of energy, road freight releases carbon emissions, route planning isn't always the best, and data isn't always shared well across supply chains [14]. These issues demonstrate the significance of utilizing analytics to propel sustainability initiatives. Moreover, although BDAC is increasingly recognized as a strategic driver for improving efficiency and performance in logistics, its role in fostering environmental, social, and economic sustainability remains insufficiently understood. As a result, the global logistics industry is becoming less willing to find a balance between fast economic growth, social equity, and environmental sustainability [15]. However, current research mainly looks at how BDAC can improve operational efficiency, and not much at all at how analytics can help logistics systems become more sustainable.

Oman's Vision 2040 says that one of its main goals is to diversify its economy, and the logistics sector is a big part of that. It helps this economic diversification and gets a lot of money from the government for infrastructure, digital systems, and trade routes between countries [16]. So, the sector has changed a lot because of national plans like Vision 2040, the Logistics Strategy 2040 (SOLS 2040), and the Net-Zero 2050 commitment [17]. Even with these changes, the industry still has issues with integrating data, being digitally mature, and being environmentally friendly [18- 20]. Also, logistics operations use a lot of energy, so Omani businesses need to use data-driven solutions to cut down on carbon emissions, use their fleets better, and make their supply chains more open [18]. To make the growth of the sector match the goals of sustainability, new ways must be found to cut down on the environmental effects of moving and storing goods [21].

Moreover, contemporary studies on BDAC primarily employ singular theoretical frameworks to clarify specific dimensions, such as technology acceptance or capability enhancement. These methodologies yield significant insights; however, utilizing a singular perspective limits our understanding of the complex, multi-faceted ways in which BDAC impacts sustainability outcomes. Previous studies rarely amalgamate these theories into a unified framework that comprehensively captures BDAC's influence at the Micro (individual), Meso (organizational), and Macro (environmental and institutional) levels. This theoretical fragmentation results in a substantial gap in clarifying the interaction among technological capabilities, human acceptance, organizational reconfiguration, and external pressures that drive sustainability transitions in logistics. This research tackles these constraints by conducting an extensive qualitative analysis of BDAC within Oman's logistics sector, employing a cohesive interrelation framework that amalgamates four theories.

## *2. STUDY OBJECTIVE*

The main research question that the study answers is: How does BDAC contribute to enhancing the three dimensions (Economic, Environmental, and Social) of sustainability in the logistics sector in Oman?

The principal contribution of this study resides in its comprehensive qualitative analysis of the BDAC-sustainability relationship. The research gives a full, multi-level view by combining four theoretical lenses: RBV, DCV, TOE, and TAM. The RBV and DCV explain the strategic benefits of BDAC, the TOE looks at the specific factors that make Oman different, and the TAM looks at how people in Oman accept and use BDAC tools. So, the study adds to and expands on the mostly quantitative, Western-focused literature by providing nuanced, context-specific insights.

## II. LITERATURE REVIEW

### 1. BIG DATA ANALYTICS CAPABILITY (BDAC)

BDAC is a complex concept and using it well is key to making the most of big data. It usually has three mains, connected parts [1, 2]:

- Big Data Infrastructure Capability: This refers to the technological foundation, encompassing the hardware, software, and network infrastructure required for the high-velocity acquisition, secure storage, and massive-scale processing of diverse data. Importantly, this includes the flexibility and scalability of cloud computing resources, as well as the integration of advanced technologies such as IoT sensors and telematics systems, which are fundamental to real-time data collection in logistics operations [3, 4].
- Big Data Management Capability: This is the organizational and procedural ability to govern the entire data lifecycle. It involves establishing rigorous protocols for data quality (accuracy, completeness, and timeliness), data security, and data integration across disparate systems (e.g., TMS, WMS, ERP), as well as ensuring data accessibility for authorized users. Effective data management is the bridge that transforms raw data streams into reliable, decision-ready information[5].
- Big Data Personnel Capability: This component represents the human capital necessary to harness the infrastructure and management capabilities. It includes not only the technical skills for data analysis and modeling (e.g., data scientists, analysts) but also the domain knowledge of logistics and managerial expertise required to interpret data insights and translate them into actionable, strategic decisions. The literature emphasizes that the synergy between technical skill and business insights is the ultimate source of value creation from BDAC [6].

Hence, a firm's BDAC is not just about having technology. It is the combined use of technology, organization, and people that enables the firm to create more value and adapt to market changes [1, 7].

### 2. BDAC

BDAC is a complicated idea, and using it correctly is important for getting the most out of big data. It usually has three main parts that are linked together [7, 12]:

- Big Data Infrastructure Capability: This is the technology that makes it possible to quickly collect, safely store, and process large amounts of different types of data. It includes the hardware, software, and network infrastructure needed for all of these things. This includes the ability of cloud computing resources to be flexible and grow, as well as the use of advanced technologies like IoT sensors and telematics systems, which are essential for collecting data in real time in logistics operations [10, 22].
- The ability to manage big data: This is the ability of an organization and its procedures to manage the whole data lifecycle. It means setting strict rules for data quality (accuracy, completeness, and timeliness), data security, and data integration across different systems (like TMS, WMS, and ERP). It also means making sure that only authorized users can access the data. Good data management is what turns raw data streams into information that is reliable and ready to be used in decision-making [23].
- Big Data Personnel Capability: This part shows the people who are needed to use the infrastructure and management skills. It includes not only the technical skills needed to analyze and model data (like those of data scientists and analysts), but also the knowledge of logistics and management needed to understand data insights and turn them into strategic decisions that can be acted on. The literature underscores that the integration of technical proficiency and business acumen is the paramount source of value generation from BDAC [24].

Thus, a company's BDAC isn't just about having technology. The company can make more money and adapt to changes in the market by using technology, organization, and people together [7, 25].

### 3. THEORETICAL FOUNDATION: AN INTEGRATED FOUR-THEORY CONTEXT

To fully understand how BDAC is accepted and affects sustainability in Oman's logistics sector, this study uses four related theories: RBV, DCV, Technology-Organization-Environment (TOE), and TAM, Together,

these theories cover the strategic, changing, local, and personal considerations that shape the link between BDAC and sustainability.

### *3.1 Strategic and Dynamic Views: RBV and DCV*

These theories look at how BDAC adds value and supports sustainability within a company.

- Resource-Based View (RBV): The RBV posits that a firm achieves a sustained competitive advantage by possessing and controlling resources that are Valuable, Rare, Inimitable, and Non-substitutable (VRIN) [8]. BDAC is conceptualized as a strategic resource that is valuable (enabling cost reduction and environmental compliance), rare (due to the integrated combination of its components), and inimitable (due to embedded organizational routines [9, 10].
- Dynamic Capabilities View (DCV): The DCV explains how the RBV advantage is sustained in dynamic environments [11]. BDAC is viewed as a dynamic capability that allows logistics firms to sense sustainability-related opportunities, seize them through operational changes (e.g., green logistics), and reconfigure their resource base (e.g., personnel training) in response to market demands [12, 13].

### *3.2 Contextual View: The Technology-Organization-Environment (TOE) Framework*

The TOE framework [14] explains how companies adopt and use new technologies by looking at three main areas:

- Technological Context: Internal and external technologies relevant to the firm (e.g., the complexity and compatibility of BDAC infrastructure).
- Organizational Context: The descriptive attributes of the firm or organization such as the size, structure, resources (linking to RBV), and the top management's support for BDAC endorsement.
- Environmental Context: The arena in which the firm conducts its business, including sector structure, government regulations. In this study, it can be attributed for example to Oman Vision 2040, Oman Logistics Strategy (SOLS 2040), Oman Net-Zero 2050, for the green logistics policies, besides the competitive pressure. The TOE framework is crucial for understanding the macro-level factors driving BDAC incorporation in Oman.

### *3.3 Individual Acceptance Views: TAM*

This theory focuses on how individual employees accept and use BDAC tools, which is important for achieving the bigger strategic goals (related to BDAC Personnel Capability).

- Technology Acceptance Model (TAM): [15]suggests that an individual's intention to use a new technology is determined by two primary beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). In logistics, if BDAC tools are seen as useful for optimizing routes and easy to use, adoption will be higher. This framework is particularly relevant to the personnel capability as it helps analyze the determinants forming the Omani workforce's willingness and ability to use BDAC tools.

### *3.4 Synthesis of the Four-Theory Framework*

In this study, the four theories are connected in the following ways:

- TOE provides the context (Omani logistics environment such as Oman Vision 2040, Oman Logistics Strategy 2040 (SOLS 2040), Oman Net-Zero 2050, and other government policies) for BDAC application.
- TAM explains the individual-level success of BDAC implementation, specifically focusing on the personnel capability required to use the BDAC resource effectively.
- RBV identifies BDAC as the strategic resource that can create a competitive advantage.
- DCV explains the dynamic process of how this resource is deployed (sensing, seizing, reconfiguring) to achieve and maintain sustainability.

## *4. LOGISTICS SUSTAINABILITY*

In the whole supply chain, sustainability involves the consideration of social, environmental, and economic factors in the processes and operations [16]. Sustainability is a broad idea, often described by the

Triple Bottom Line (TBL) approach. This means companies need to manage and report on their economic, environmental, and social performance at the same time.

These three areas are closely linked:

- Economic Sustainability: This component is all about the long-term financial health and profitability of logistics operations. In logistics, this involves getting the most out of what you currently have, cutting costs (particularly for fuel and maintenance), preserving the proper amount of inventory, and making sure the complete supply chain is strong. In this way, BDAC is particularly essential since it delivers operations anticipatory insights that help them run more smoothly and efficiently [34].
- Environmental Sustainability (Green Logistics): This is probably the clearest facet of sustainability in logistics. This aspect is all about making the world a better place by reducing greenhouse gas emissions ($CO_2$, NOx) from transportation, cutting down on waste from packing or additional inventory, and using less energy in warehouses [34, 35]. These initiatives in Oman are quite similar to what the government is doing to promote green technologies and make the country's quickly increasing ports and transportation networks less harmful to the environment. Oman Vision 2040, SOLS 2040, and the Net-Zero 2050 promise all talk about these plans.
- Social Sustainability: This part looks at how logistical activities affect individuals and their communities. It means treating workers fairly, keeping health and safety standards high (particularly for drivers and warehouse workers), being responsible when interacting with local communities, and making sure that the supply chain is open and honest, including ethical sourcing. So, BDAC improves social sustainability by creating data that can be used to keep an eye on working conditions, make things safer, and make the supply chain more open [36].

The logistics sector in Oman has the unique challenge of balancing the country's commitment to protecting the environment with the rapid growth of its infrastructure under Vision2040. This makes it very important to have both economic and environmental sustainability [21].

## *5. RESEARCH GAP AND CONTRIBUTIONS*

Studies on Big data Analytics Capability in logistics and supply chain as whole have increased rapidly in the last few years. Despite that, much of the research remains strongly rooted in the operational performance. Empirical studies normally present BDAC as s strategic asset that improves efficiency, responsiveness, resilience, and competitive advantage by enhancing forecasting accuracy, system integration and decision making [4, 17- 21]. Likewise, some large-scale quantitative studies further reinforced this perspective by linking BDAC to both operational and financial outcomes [19, 22- 24]. Such studies neglected to address sustainability as a central objective by its own, instead it was treated as a secondary or indirect.

Additionally, some scholars have begun to focus on the relationship between BDA/BDAC and sustainability. However, this domain of study remains fragmented and limited in scope. In this area, much research focuses primarily on environmental outcomes such as emissions reductions or energy efficiency, while giving less consideration to social sustainability or is unable to balance the priorities among the three pillars of sustainability (Economic, Social, and Environmental) [25- 29]. Therefore, an in-depth Triple-Bottom-Line analysis of how BDAC supports logistics sustainability is still relatively limited. Moreover, contextual aspects represent a significant gap in the literature because the mainstream of BDAC studies are conducted in developed economies and digitally advanced workplaces [1, 30- 33]

Empirical evidence from logistics in the developing and emerging countries remains limited specifically within context which is characterized by limited expertise, fragmented systems, and evolving governance policies. Hence, this gap is evident in the GCC countries thus the applicability of existing insights is limited [13, 34- 37] which is resulting in an incomplete understanding of the role of BDAC plays in sustainability.

Accordingly, this study addresses these limitations by advancing a multi-level, sustainability-focused view of BDAC in an emerging logistics economy. Rather than prioritizing operational or financial performance, it examines how BDAC enables triple-bottom-line sustainability, treating environmental, social, and economic outcomes as interconnected rather than incidental. Drawing on empirical evidence from the logistics sector in Oman, the principal contribution of this study resides in its comprehensive qualitative

analysis of the BDAC-sustainability relationship. It makes three key contributions. First, it gives a multi-level view by combining four theoretical lenses: RBV, DCV, TOE, and TAM. The RBV and DCV explain the strategic benefits of BDAC, the TOE looks at the specific factors that make Oman different, and the TAM looks at how people in Oman accept and use BDAC tools. Hence, it demonstrates that sustainability outcomes depend not only on technological investment, but also on human analytical capability, governance clarity, and organizational learning. Second, it advances theory by integrating Micro-Meso-Macro changing aspects into BDAC analysis, offering a more nuanced explanation of why sustainability outcomes vary across organizations. Third, it provides empirical insight from an emerging logistics economy, repositioning BDAC research beyond operational optimization toward a more holistic understanding of analytics capability as a driver of sustainable logistics development. So, the study adds to and expands on the mostly quantitative, Western-focused literature by providing nuanced, context-specific insights.

## III. RESEARCH METHODOLOGY

### *1. RESEARCH CONTEXT*

Oman Vision 2040 and the Sultanate of Oman Logistics Strategy 2040 (SOLS 2040) seek to develop Oman's logistics industry and establish the country as a center for global logistics. The Vision and the Strategy also intend to increase employment in the logistics industry to 300,000 by 2040, hopefully raising its ranking to among the top ten in the Logistics Performance Index (LPI) and increasing its contribution to GDP by 14% [38]. Based on this, Oman represents an appropriate context for investigating the role of BDAC on sustainability. The sample is selected from medium to large companies in Muscat, Barka, Sohar, Duqum, and Salalah, where important logistics businesses exist in airports, seaports, and free zones and where they have driven logistics development through public-private partnerships and technological innovation.

### *2. RESEARCH DESIGN*

Due to the exploratory nature of the research question, this study employed a qualitative research design. Qualitative inquiry facilitates a comprehensive analysis of organizational development, [39] therefore, the application of BDAC is expected to improve sustainability in the logistics sector. Additionally, it was mentioned that BDAC not only affect sustainability factors external to the industry, but also the important internal issues of increased efficiency, cost savings, and competitiveness. Consequently, a qualitative approach is feasible for understanding people's actual experiences with BDAC as well as their interpretations of its nature and role in sustainability.

Semi-structured interviews were conducted between March and July 2025. Each session lasted between 45 and 90 minutes and was held in either Arabic or English, depending on what the participant wanted. The audio was recorded and transcribed with the participants' permission, and all of the interviews were transcribed correctly. Also, an experienced English-speaking academic translated and checked the Arabic version3.3 Participants and Sampling. A purposive sampling strategy was utilized to select participants possessing leadership qualities, expertise, and managerial roles in operations, IT, data analysis, or sustainability management. The purposive sampling enables a variety of perspectives and experiences within a specific context, thereby enriching the study's theoretical diversity and yielding more comprehensive results and a deeper understanding of complex issues [38].

Participants were selected from eight organizations throughout Oman, showcasing a variety of organizational sizes and ownership structures, and serving as a central hub for numerous corporate headquarters, imports, and logistics, including airports, ports, and logistics firms of various sizes. Twenty-five people were chosen and interviewed from eight organizations in Oman's main logistics hubs: Muscat, Barka, Sohar, Duqm, and Salalah. The choice to use a final sample of 25 interviews was made because logistics are complicated and thematic analysis needs to be done carefully.

As the logistics structure involves many different roles, it was important to include views from operational, tactical, and strategic levels, as [40] recommend for developing strong themes. While saturation was reached after about 20 interviews, the sample was increased to 25 to make sure the themes were stable

across different job functions. This follows [39] suggestion that studies of complex organizations often need 20 to 30 interviews. In line with [41], the study also aimed for meaning saturation, not just code saturation, to better understand differences in BDAC use, capability changes, and sustainability practices.

### *3. DATA SATURATION*

Data saturation was approached as a two-stage process, distinguishing between code saturation and meaning saturation, in line with established qualitative research practice. Code saturation refers to the point at which additional interviews no longer generate new first-order codes or topical categories. Meaning saturation, by contrast, relates to whether the emerging themes are sufficiently rich, well-developed, and conceptually complete. Open coding was carried out alongside data collection during the early stages of analysis. After approximately 20 interviews, no substantive new codes related to Big Data Analytics Capability, sustainability, or logistics practices were identified, indicating that code saturation had been reached. Data collection nonetheless continued, resulting in a total of 25 interviews, to ensure that meaning saturation was fully achieved.

The final five interviews did not introduce new themes or alter the overall thematic structure. Instead, they added depth and nuance to the existing analysis, particularly by capturing variation across firm sizes and logistics subsectors. These additional interviews helped refine the interpretation of how analytics capabilities were enacted in practice, without expanding the thematic framework itself. The continued absence of new themes in the later interviews provided clear evidence of thematic stability. On this basis, the decision to conclude data collection reflected not only the lack of new codes, but also confidence that sufficient interpretive depth and analytical completeness had been reached across the dataset.

### *4. SAMPLE COMPOSITION*

Table 1 provides an overview of the study participants. The sample includes leadership positions, IT, operations, logistics, sustainability, and management from logistics organizations in Oman. This mix ensures a variety and depth of strategic, managerial, and technical perspectives on BDACand sustainability practices as well as adding.

**Table 1.** Participants' profile.

| No. | Job Level/Category | Positions | No. of Participants |
|---|---|---|---|
| 1 | Executive Leadership | CEO, VP, GM, CCAO, Deputy CEO, Assistant GM | 6 |
| 2 | Sustainability, Safety and Energy | VP, Energy Expert | 5 |
| 3 | Operations and Logistics Management | Manager, Assistant Manager, Specialist, Officer | 5 |
| 4 | Information Technology and Data Analytics | Manager, Head, Analyst, Specialist, Project Manager, Business Intelligence Analyst, Senior Systems Admin | 5 |
| 5 | Human Capital, Admin. and Business Development | Manager | 4 |
| Total No. of Participants | | | 25 |

### *5. DATA ANALYSIS*

The interview transcripts were analyzed using thematic analysis following Braun and Clarke's (2006) six-phase procedure; Data Familiarization, Initial Coding, Theme Development, reviewing themes, Defining and naming themes, and Reporting using MAXQDA software.

## 6. TRUSTWORTHINESS

### 6.1 Ethical Considerations

This study was conducted in line with established ethical standards for qualitative research involving human participants. Ethical considerations were addressed throughout the research process, including informed consent, participant anonymity and confidentiality, translation safeguards, and secure data handling. Firstly, informed consent was obtained from all participants before data collection began. Each interviewee was given a clear explanation of the study's purpose, the voluntary nature of participation, and their right to reject specific questions or withdraw at any time. Secondly, consent was secured prior to audio recording, and participants were informed about how the interview data would be used for research purposes only. Thirdly, participant anonymity and confidentiality were carefully protected. For example, identifying information - including names, organizational affiliations, and other potentially revealing details were removed during transcription and analysis. Also, anonymized identifiers were used in all transcripts, analytical files, and reported excerpts. Finally, contextual details were paraphrased or generalized to prevent indirect identification, particularly in cases involving senior roles or distinctive organizational practices.

Furthermore, given the bilingual nature of the research, specific steps were taken to safeguard the translation process. Interviews conducted in Arabic were transcribed verbatim before being translated into English. The translation process focused on preserving conceptual and semantic meaning rather than producing literal word-for-word translations, especially for technical terms related to analytics, governance, and sustainability. In addition, some key excerpts used in the analysis were reviewed to ensure that meaning was retained across languages, reducing the risk of misinterpretation.

In regards to data security, it was treated as a top priority throughout the study by the way of storing audio recordings, transcripts, and analytical files which were stored on password-protected devices accessible only to the research team, with digital files encrypted where possible and audio recordings were used solely for transcription and verification purposes.in addition, no raw data was shared beyond the research team, and all analytical transcripts contained no personally identifiable information.

### 6.2 Error Analysis

This study acknowledges that its qualitative, interview-based design carries natural risks of bias, including interview-related bias, translation issues between Arabic and English, and the possibility that managers may overstate sustainability practices. These concerns were considered from the outset and addressed systematically in order to strengthen the credibility and trustworthiness of the findings. Interview bias, such as social desirability or strategic self-presentation, was managed through purposeful sampling across organizational roles, hierarchical levels, and logistics subsectors. By including operational, managerial, and strategic participants, the study was able to cross-check perspectives and avoid reliance on any single viewpoint. Interviews relied on open-ended questions and follow-up probes to clarify responses and draw out concrete examples, while the analysis focused on patterns that recurred across interviews rather than isolated statements.

Potential translation bias was addressed through a structured Arabic-English process. Interviews conducted in Arabic were transcribed verbatim before translation, with an emphasis on preserving conceptual meaning rather than literal wording. Key excerpts were reviewed to ensure that meaning remained consistent across languages. The analysis also accounted for the risk of managerial overstatement by prioritizing enacted practices over aspirational claims, examining sustainability statements alongside described routines, decision processes, and analytics-supported actions. While these steps cannot eliminate bias entirely, clearly documenting how such issues were managed enhances transparency and reinforces the dependability and credibility of the findings.

## IV. FINDINGS AND THEMATIC ANALYSIS

### *1. QUANTIFYING QUALITATIVE INSIGHTS*

Although the primary aim of this study is interpretive rather than statistical, descriptive quantification was used to improve transparency and analytical clarity. In line with established qualitative research practice, the number and proportion of participants referring to each theme and sub-theme are reported to indicate how prevalent these issues were within the dataset, without suggesting statistical generalization beyond the study sample.

Across the 25 interviews, the three core themes appeared widely. Personnel capability emerged as the most frequently discussed theme, mentioned by 21 participants (84%), often in relation to data literacy, analytical confidence, and organizational learning habits. Traceability was raised by 18 participants (72%), typically in discussions of data visibility, integration challenges, and trust in analytics outputs. Green logistics, or eco-friendly logistics, was explicitly mentioned by 16 participants (64%), most often in connection with fuel efficiency, route optimization, and waste reduction. At the sub-themes level, individual analytical competence was highlighted by 19 participants (76%), underscoring its central role in effective analytics use. In addition, issues related to governance clarity and data ownership appeared in 17 interviews (68%), pointing to the importance of clear roles and accountability. In the same vein, planning was discussed by 15 participants (60%), while environmental efficiency practices were mentioned by 14 participants (56%). However, social sustainability concerns such as workforce well-being and transparency were less frequently expressed, appearing in 9 interviews (36%).

These descriptive frequencies are not intended to signal importance or causal influence. Instead, they provide context for the qualitative interpretations that follow. Themes mentioned less often were not treated as analytically weaker, but were examined in relation to their contextual regard, sectoral relevance, and the depth of discussion in which they emerged. Thus, this combined qualitative descriptive approach strengthens interpretive rigor by linking thematic importance with rich explanatory interpretations, while remaining tightly aligned with qualitative research standards.

### *2. THEMATIC ANALYSIS*

The thematic analysis revealed significant insights regarding the perception and utilization of BDAC in promoting sustainability within Oman's logistics sector.

#### *2.1 Theme 1: BDAC as a Facilitator of Eco-Friendly Logistics (Environmental Sustainability)*

One of the most important things that came out of the interviews was a clear, positive link between BDAC and environmental sustainability, especially in Green Logistics. Managers viewed BDAC as a crucial means to collect comprehensive, real-time data previously unavailable, facilitating their ability to detect changes as outlined in the DCV.

The study found three main sub-themes:

#### *2.2 Planning the best route and load*

A lot of people said that advanced BDAC tools that used real-time traffic, weather, and delivery data let them go beyond static route planning. One person said, "We now look at routes and improve them so that we don't have to make extra trips, which saves gas." The refrigeration sensors also help keep food from going bad, which cuts down on waste (NRJ1). Companies can "seize" the chance to save fuel and cut down on waste, which means they can also cut down on emissions.

#### *2.3 Maintenance that can be predicted for fleet efficiency*

It was said that using telematics and sensor data for predictive maintenance was very important. Logistics companies make sure their vehicles run at their best fuel efficiency by planning for equipment failures. Also, this feature reduces the number of unexpected breakdowns, which can cause expensive and harmful emergency rerouting. One interviewee said, "So for us, in our module, we're collecting data on how well the assets or infrastructure we maintain are working." Departments that are in charge of keeping assets and

equipment in good shape and rolling equipment. So, gathering the information tells us about the land services, which we call "preventive maintenance," and when we should do it. (DQM1).

### *2.4 Logistics and Warehousing that Use Less Energy*

We used BDAC to look at how energy is used in big Omani warehouses and distribution centers. Companies could save a lot of energy and reduce their carbon footprint by combining data from smart meters and environmental sensors to improve lighting, cooling, and space use. This theme emphasizes the "Reconfiguring" part of the DCV, which is when data insights cause operational processes to be redesigned. One person said, "If we use energy more efficiently, it means we will cut down on our emissions." If we make it smaller, it means we will have more money coming in. (SOP3)

## *3. THEME 2: THE CRITICAL ROLE OF PERSONNEL CAPABILITY (ECONOMIC SUSTAINABILITY)*

The results showed that having the right Big Data infrastructure is important, but the skills and abilities of the people using the data are what really matter for economic sustainability. This theme shows how important people are in making money from data. So, personnel capability is the most important part of BDAC because it is what makes other parts, like technology and infrastructure, able to deliver value. Human skills in analytics, analytical thinking, and a digital mindset are what make insights useful, trustworthy, and actionable. This is different from "purchasable" resources. Participants emphasize that skill deficiencies directly impede BDAC outcomes, whereas strong personnel competencies foster more distinct performance improvements, particularly in sustainability, resilience, and innovation. The analysis identified two principal sub-themes:

### *3.1 Advanced Risk Management and Cost Optimization*

Seniors and managers stressed that BDAC-enabled workers could turn complicated analytical reports into strategies that save money and can be put into action. This goes beyond just optimizing routes to include accurate demand forecasting, which lowers the cost of holding inventory and cuts down on waste (a big benefit for the economy and the environment). Also, being able to look at market and operational data helps companies better handle the financial risks that come with supply chain problems, changing fuel prices, and delays at customs. One person said, "So logistics is part of the supply chain that moves goods from one place to another, but in between that, there is a lot of data that you need to be able to analyze in order to lower your costs, be more efficient, and also manage the cost." So, if you have data analytics, it will help you figure that out. "Be more efficient, cost-effective, and on time" (SLL1).

### *3.2 The Strategic Talent Gap*

One major problem that kept coming up was the lack of local Omani talent with the right mix of advanced data analytics skills and deep knowledge of logistics. This "Talent Gap" makes it hard to fully use BDAC for long-term economic growth. Interviewees stressed that the government needs to put money into specialized education, training, and awareness programs to close this gap and make sure that the sector's growth continues under Oman Vision 2040. One participant said, "Without having the data." Your business will never be able to work well. Your business will never be able to get things done. There is a big difference. If you want to be sustainable, you need to "boost this up and use your current data" (TRN1).

This suggests that the "Reconfiguring" of human resources is the most difficult but also the most important dynamic capability for Omani companies.

## *4. THEME 3: ENHANCING TRACEABILITY AND TRANSPARENCY (SOCIAL SUSTAINABILITY)*

The theme of Traceability and Transparency, which BDAC made possible, addressed the social side of sustainability, which is often hard to measure. This skill has a direct impact on how the company interacts with its employees, partners, and the community as a whole. Two main sub-themes came up:

### *4.1 Enhanced Worker Safety and Well-being*

BDAC played a big role in making sure that workers were safe and followed labor laws. Companies can keep an eye on driver hours, stop accidents caused by fatigue, and make sure they are following Omani labor laws by looking at data from telematics, wearable devices, and internal systems (Seizing). One of the managers who was interviewed said, "We have 24 hours of video monitoring, and if someone, for example, is sleeping in the car or taking more time than they should, like 5 minutes, or they stop for more than 10 minutes, they will get an alert" (MDL2). Another participant also stated "There are lots of sensors there, environmental sensors, so if sometimes they handle some dangerous chemical material and If there is any leak leakage, they will get alarms, and evacuation immediately will be asked. Everyone will need to evacuate" (TRA1).

### *4.2 Supply Chain Ethics and Community Trust*

BDAC gives you the full picture you need to source ethically and keep the trust of the community (Sensing). By keeping track of where goods come from, companies can make sure that the materials they use come from ethical and responsible sources, which lowers the risks of using forced labor or other bad practices. Sharing and analyzing data makes this transparency possible, which builds trust with both consumers and regulators. This brings the logistics sector in line with what society expects as a whole. A senior sustainability participant, for instance, says, "It's part of the CSR." We are also using two other technologies. The first one has to do with pollution in the environment. So, if I'm not mistaken, we have about five or six "environmental" air stations that measure the quality of the air (SOP4).

Furthermore, the data can be used to optimize delivery schedules to minimize noise and traffic disruption in local communities, demonstrating a commitment to social responsibility. This is assured by one participant as explained: "There are sensors invested by CA in the Airport for environment for that emission. And even not for emission as well. It's even with any noise or the sound of the aircraft as well. There are some devices or full systems that are installed in different locations in the airport areas. So even with the. That's while landing and take-off. There is a specific sensor and there is a specific algorithm from that system which gives you an alert and gives you a daily report regarding this" (OAR1).

## *5. ROBUSTNESS/GENERALIZATION ANALYSIS*

Across logistics firms of different sizes and subsectors, the same three themes - green logistics, personnel capability, and traceability kept reappearing, even though their prominence varied. Larger firms usually had more formal analytics systems and clearer governance structures in place. Yet these strengths did not reliably translate into better sustainability outcomes. In practice, organizational dormancy, fragmented data ownership, and limited cross-functional use of insights often reduced the impact of otherwise well-designed systems. Smaller sized firms faced tighter technological constraints, but they were often quicker to adapt in how analytics was actually used. In these organizations, personnel capability and managerial commitment were central to turning data into action. Several smaller firms reported meaningful sustainability improvements despite relatively simple analytics infrastructures, suggesting that the way capabilities are organized and applied can matter more than the scale of investment itself.

In terms of subsectors, traceability and environmental monitoring in ports stood out, largely because of regulatory pressure and safety requirements. Here, personnel capability determined whether analytics informed day-to-day operational decisions or remained confined to compliance reporting. In warehousing, green logistics and personnel capability were more prominent, with sustainability outcomes closely linked to energy use, space utilization, and routine operational choices. In land transport, traceability and green logistics were tightly connected through route optimization, fuel monitoring, and delivery tracking, although fragmented data sources and reliance on external partners often limited end-to-end visibility.

Overall, these patterns point to the robustness of the three themes across different contexts. While firm size and subsector shape how green logistics, personnel capability, and traceability are expressed, sustainability outcomes from BDAC depend far less on organizational scale or industry and far more on how analytics capabilities are configured, governed, and embedded in everyday decision-making. This supports

the transferability of the findings across emerging logistics economies, while also underscoring the need for context-sensitive approaches to capability development.

However, the findings of this study are not intended to support statistical generalization. Instead, they contribute through analytical generalization, in which empirically grounded mechanisms are expected to hold in settings that share comparable contextual conditions. From this perspective, the extent to which the findings apply to other Gulf Cooperation Council (GCC) countries and to developing economies more broadly depends on a set of clearly identifiable boundary conditions. These include differences in institutional and regulatory environments, cultural differences, levels of digital and analytics maturity, labor-market conditions and skill availability, as well as the structure and degree of fragmentation within logistics systems.

## *6. LINKING BDAC COMPONENT (INFRASTRUCTURE, MANAGEMENT, PERSONNEL)*

To ground the findings more clearly in empirical evidence, the study connects the core three elements of BDAC- technological, management, and personnel capability - to the sustainability performance indicators described by interview participants. While sustainability outcomes were not measured directly, respondents consistently referred to familiar operational metrics, making it possible to draw clear links between BDAC components and the sustainability KPIs commonly used in logistics.

Technological infrastructure was most often associated with environmental efficiency, particularly fuel consumption and $CO_2$ emissions. In this regard, some participants explained how telematics systems, real-time vehicle monitoring, and route-optimization tools helped improve routing decisions, reduce time, and make better use of vehicle capacity. At the same time, it became clear that technology on its own was not enough because where systems were poorly integrated or analytics outputs were not regularly reviewed, improvements in environmental performance remained limited.

In terms of management capability, the way analytics was managed and governed strongly influenced whether sustainability indicators were actually monitored and acted upon. For example, clear data ownership, structured reporting procedures, and well-defined responsibilities made it easier to integrate fuel efficiency, emissions, health, safety, and environmental (HSE) metrics into regular performance evaluations. In contrast, scattered data often weakens the role of sustainability data in day-to-day operational decisions.

On the other hand, personnel capability emerged as especially important for outcomes tied to everyday activities, particularly health and safety issues. Interviewees noted that data literacy and analytical confidence shapes whether analytics insights led to safer practices and early risk prevention. Organizations with stronger analytical skills were better able to use dashboards and alerts to reduce safety incidents, while those with more limited capability struggled to turn available data into meaningful action.

In short, the findings show that the sustainability KPIs are not driven by any single BDAC component in isolation. Consequently, improvements in environmental efficiency depend on the alignment between technology and management, while gains in safety and social outcomes rely heavily on personnel capability. Thus, BDAC contributes more to sustainability when analytics capabilities are actively used, well managed, and embedded in everyday decision-making.

## *7. STUDY CONTRIBUTION*

This study connects Micro-level research on technology adoption, such as TOE and TAM, with larger, Macro-level strategic management theories like RBV and DCT. It puts forward a complete framework that connects the adoption, effective use, and long-term effects of BDAC, which is a good place to start with the analyses that follow. In addition to linking these theoretical viewpoints, the study also shows how analytics capabilities are always changing. They are shaped not just by the use of new technologies, but also by the ongoing learning that happens in the organization. This shows a clear commitment to being flexible and adaptable in the face of quickly changing digital tools. It examines how the capabilities of Big Data Analytics

(BDAC) facilitate sustainability in logistics companies, as depicted in Figure 1. It uses a multi-tiered framework based on well-known organizational theories, as follows:

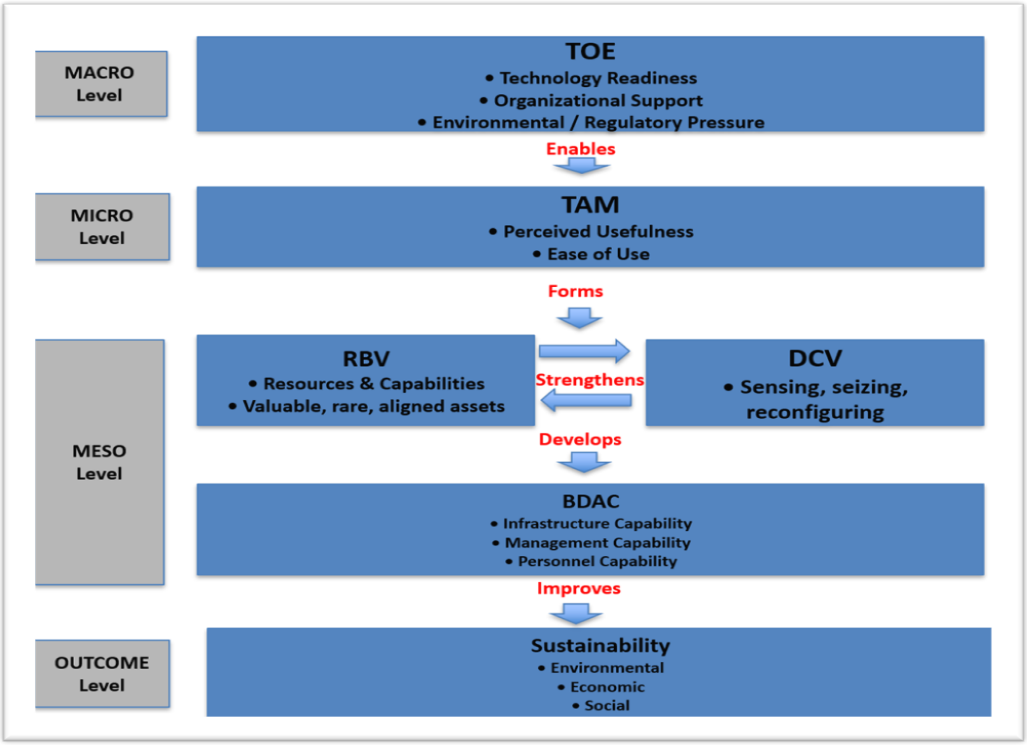



FIGURE 1.A Relationship comprehensive proposed framework.

- Macro-Level (The Overall Perspective): The Technology-Organization-Environment (TOE) framework is used to understand the bigger picture. It looks at the outside forces and pressures that affect a company's willingness to spend money on analytics. These factors determine when and if a company will focus on using big data.
- Micro-Level (Individual Employees): The TAM focuses on the employees in the company. It suggests that how useful and easy employees think the technology is affects how well it fits into their daily tasks. This personal acceptance is very important for making sure that the company's investment in analytics pays off.
- Meso-Level (The Organization Itself): This level looks at how the organization builds up its analytics skills. The RBV sees BDAC as a one-of-a-kind and useful resource in this sense. Strong management and data governance are necessary for it to have an effect. Dynamic Capabilities Theory (DCT) shows how companies use analytics to find potential customers, take advantage of them, and adapt to new sustainability needs. The interaction of these two theories shows how BDAC changes from a simple technological investment into a core part of the organization that keeps getting better.
- Outcome-Level (The Impacts): The framework shows that having strong analytics skills leads to better environmental, economic, and social sustainability. It's not just about having the technology; it's also about how it's used in the right context, with user acceptance, and with internal development.

In Addition, the findings indicate that Big Data Analytics acceptance in Oman is shaped largely state-led context, which differs in important ways from the market-led adoption methods normally reported in developed economies. Recognizing the difference between these contexts explains the underlying processes through which analytics adoption is initiated and later translated into organizational capability and

sustainability outcomes. For example, in the Omani, BDA acceptance is strongly influenced by state-driven plans such as Oman Vision 2040 and the logistics strategy, the public-sector investment priorities, and regulatory prospect directed at the logistics sector and technological infrastructure. On the other hand, in developed economies it is driven by market settings such as competitive force, cost, and push from customers for efficiency, transparency, and sustainability performance. Comparing these contexts highlights an important causal characteristic. In state-led environments such as Oman, BDA adoption is often policy-enabled but capability-contingent, meaning that adoption alone does not guarantee sustainability impact. In market-led environments, adoption is performance-driven, with feedback mechanisms that is more directly connected to operational, environmental, and social outcomes.

## V. DISCUSSION OF FINDINGS

The thematic analysis provides robust, context-specific evidence that BDAC is a critical determinant of logistics sustainability in Oman. Here, we use four theories to put the findings together and show how BDAC and sustainability are related on different levels. Thus, the findings of this study both confirm and significantly extend exciting research on BDACand sustainability.

### *1. BDAC AS AN ENABLER OF GREEN LOGISTICS (ENVIRONMENTAL SUSTAINABILITY)*

The finding that BDAC enables Green Logistics (Theme 1) is primarily explained by the TOE framework and the RBV/DCV lens.

- TOE Context: The Environmental Context (Oman Vision 2040, Oman Logistics Strategy 2040 (SOLS 2040), Oman Net-Zero 2050, and Oman government's push for green logistics) provides the external pressure and opportunity that drives firms to implement BDAC. The Technological Context (availability of advanced BDAC infrastructure) is the necessary enabler.
- RBV/DCV Link: From an RBV perspective, the BDAC infrastructure and management capability are valuable resources that enable firms to reduce costs and environmental impact through optimized route planning and predictive maintenance. This lets companies move from simple, easy-to-copy resources to a more complicated, hard-to-copy operational advantage. The DCV describes how companies can take advantage of the environmental threat (high emissions) by using BDAC to change how they do business (optimized routes), which will lead to better environmental performance over time.

In this context, certain prior research indicates that BDAC improves environmental sustainability by optimizing routes, lowering emissions, and enabling predictive maintenance. These studies consistently demonstrate that BDAC enhances green logistics performance in the presence of a robust digital infrastructure [41-45]. These results are very similar to the environmental themes that were found in this study. However, unlike technologically advanced economies where acceptance is primarily market-driven, the Omani case shows that state-led sustainability agendas - particularly national visions and decarbonization commitments - play a central role in motivating BDAC acceptance. This is different from how people in Europe, East Asia, and North America embrace things. In those places, competition and customer demand are the main forces [10, 12, 15, 28, 46].

### *2. THE CRITICAL ROLE OF PERSONNEL CAPABILITY (ECONOMIC SUSTAINABILITY)*

The strong emphasis on Personnel Capability (Theme 2) as the bottleneck for economic sustainability is a crucial finding that highlights the importance of the individual acceptance theories (TAM) and the RBV/DCV lens.

- RBV/DCV Link: From an RBV perspective, the highly skilled Omani personnel capable of translating BDAC insights into strategic action represent a rare and inimitable resource. The identified 'Strategic Talent Gap' underscores the non-substitutability of this human resource. The DCV confirms that the ability to 'Seize' economic opportunities is critically dependent on the analytical skills of the Omani workforce.
- TAM Link: The success of BDAC in achieving cost optimization is based on the individual employee's acceptance and use of the analytical tools. The 'Strategic Talent Gap' directly relates to the Perceived Ease

of Use (TAM) among some employees. investment in education, training, awareness, and expertise is therefore necessary to improve this issue, ensuring the BDAC resource is actually utilized to generate economic value.

Therefore, in terms of economic sustainability, the findings not only reflect global trends but also add important nuance. Research from advanced economies such as the US, Australia, and Western Europe indicates that analytics talent is broadly integrated into logistics operations [42- 47]. In contrast, evidence from developing countries like India, Pakistan, Malaysia, Kenya, and Brazil highlights persistent skill shortages that continue to constrain the effectiveness of BDAC [48-55]

This study reinforces these observations, demonstrating that in Oman, personnel capability within big data analytics is both the most critical and the most limited factor influencing BDAC's contribution to economic sustainability. In addition, this aligns with some evidence from GCC countries like Saudi Arabia, Bahrain, and the UAE, where analytics skill gaps and readiness issues remain key obstacles [13, 34, 56- 60]. Thus, while global studies often assume human capability is readily available, this study demonstrates that in Oman, like across many developing economies, personnel capability represents the primary bottleneck in achieving BDAC-driven economic outcomes.

### *3. ENHANCING TRACEABILITY AND TRANSPARENCY (SOCIAL SUSTAINABILITY)*

The link between BDAC and Social Sustainability through Traceability and Transparency (Theme 3) is best understood through the TOE framework and the DCV.

- TOE Context: The Organizational Context (top management support for ethical practices) and the Environmental Context (societal pressure for transparency and labor compliance) drive the firm's motivation to use BDAC for social good.
- DCV Link: The BDAC's role here is to sense and provide valuable information (RBV) that enhances the firm's reputation and social license to operate. The use of telematics for worker safety is a practical example of the DCV's reconfiguring mechanism, where data insights lead to the redesign of operational policies to improve social welfare and therefore, the expectation of using the technology for compliance and safety drives its use. Consequently, these findings suggest that BDAC's contribution to sustainability arises from a multifaceted interplay of contextual conditions (TOE), strategic capabilities (RBV/DCV), and individual acceptance and usage behaviors (TAM).

Moreover, the results of this study on social sustainability both mirror and augment the current literature. Prior studies have demonstrated that BDAC can improve transparency, traceability, worker safety, and ethical logistics practices [14, 15, 66], and these results were distinctly observable in the present study as well. This study demonstrates that Omani logistics companies utilize BDAC not only for compliance but also to establish social legitimacy, fulfill societal and regulatory expectations, and enhance worker protection. This hint is in line with other studies that say BDAC has a bigger impact on social responsibility and public trust in emerging markets than it does in developed markets [14, 36, 45, 67, 68].

These findings collectively contest the prevalent assumption in BDAC-sustainability research that the relationship is uncomplicated and solely technology-driven [7, 45, 69]. Furthermore, a significant portion of the current literature conceptualizes BDAC as a singular, cohesive entity. Conversely, this study demonstrates that its influence arises from the interaction of three distinct capability dimensions - Big Data Infrastructure Capability, Big Data Management Capability, and Big Data Personnel Capability - alongside contextual pressures (TOE), dynamic reconfiguration processes (DCV), and individual acceptance behaviors (TAM). By elucidating these concepts, the study addresses recent demands to elucidate the micro-foundations of BDAC [31, 66, 70, 71] and illustrates the application of BDAC in practical logistics contexts, particularly within a developing economy like Oman's logistics ecosystem.

### *4. COMPARATIVE EVALUATION FROM DEVELOPED VS. DEVELOPING ECONOMIES*

Table 2 provides a comparison between developed and developing countries and the current study.

**Table 2.** Comparative evaluation from developed vs. developing economies.

| Theme | Developed Countries | Developing Countries | Current Study (Oman) |
|---|---|---|---|
| Green Logistics | Analytics -enabled green logistics is integrated into formal sustainability strategies and governance systems. BDAC supports efficiency activities such as route optimization, emission monitoring, and energy management through standardized KPIs. Sustainability value is driven more by governance and readiness than by the technology alone [61-65] . | Sustainability outcomes from BDAC are uneven and largely indirect. Here the environmental gains mainly stem from efficiency and cost reduction. Social sustainability remains weak and its impact depends on complementary capabilities rather than analytics investment itself [66-69]. | A shift from efficiency-focused (green logistics) to Tribble-Bottom-Line sustainability occurs only when clear governance, skilled personal, and usable analytics jointly support sustained decision-making rather than isolated optimization efforts. |
| Personal Capability | Personal capability is often understood as a built-in organizational resource through which BDAC shapes sustainability outcomes. In this view, analytics tend to work through broader supply chain capabilities such as integration, flexibility, and resilience. It also depends on analytical skills, learning routines, and the managerial support that is embedded in governance structures [70-73]. | Empirical studies explicitly suggest that personal capability is not merely a background condition but a real constraint. Studies draw a clear line between technological BDAC and personal BDAC showing that sustainability outcomes heavily depend on analytical skills, data literacy, absorptive capacity, and ongoing learning. It is emphasized that without capability development, technology on its own rarely brings meaningful sustainability value [69, 74-77]. | Shows that personal capability operates as a multi-level mechanism that connects individual confidence and competence at the Micro level, with organizational learning and role clarity at the Meso level and also reflecting the market level constraints at the Marco level. This explains why BDAC driven sustainability vary across firms. |
| Traceability | Traceability is commonly framed as a socio-technical capability enabled by technologies such as blockchain IoT, and AI, but strengthened in practice by governance, standardization, and coordination across supply chain players. It demonstrates that even in the technologically advanced settings, effective traceability depends less on technology availability alone but also on aligned incentives, system integration and organizational support [78-81]. | Traceability remains shattered and uneven. According to these claims, sustainability impacts are often achieved through partial visibility and connectivity which is shaped by differences in adoption readiness, governance gaps, data-sharing barriers and weak ecosystem alignments. As a result, many initiatives create isolated "visibility island" rather than end-end accountability [16, 53, 82, 83]. | The findings show that traceability becomes meaningful for sustainability only when data ownership, system usability, and cross organizational integration are firmly in place. Without these conditions, traceability efforts tend to deliver superficial visibility that fall short of supporting really environmental and social parts of it. |

## VI. IMPLICATIONS, CONCLUSION, AND FUTURE RESEARCH

### 1. IMPLICATIONS

The results show that BDAC helps logistics companies move from just meeting requirements to actively promoting new ideas for sustainability.

#### 1.1 Theoretical Implications

This article posits a theoretical correlation between BDAC and the enhancement of Logistics Sustainability in its economic, environmental, and social aspects within the framework of Oman. The study established a comprehensive, multi-dimensional understanding of BDAC as both a technological facilitator and a strategic dynamic capability for sustainability transformation, grounded in four theoretical frameworks: RBV, DCV, TOE, and TAM. It showed that BDAC is a Valuable, Rare, and Inimitable (VRIN) resource that, when used as a dynamic capability, is the key to Omani logistics companies being able to sense and respond to the complex needs of sustainable operations. This way, they can keep a competitive edge in line with Oman Vision, the Logistics Strategy, and the Net-Zero commitment. Consequently, a holistic relationships framework is proposed that connects the adoption, evolution, and enduring impact of BDAC.

#### 1.2 Managerial Implications

Omani logistics leaders and managers shouldn't think of BDAC as just an IT investment; they should think of it as a strategic capability. Investing in Big Data Personnel Capability (education, training, awareness, and expertise) is essential, as human analytical skills are required to transform data insights into enduring operational modifications (e.g., enhancing last-mile delivery to decrease emissions). This research enhances theoretical frameworks by integrating studies on technology adoption and strategic management in the realm of digital sustainability. It shows that BDAC's real value isn't just gathering data; it's also turning it into useful information that helps with sustainability.

#### 1.3 Policy Implications

Policymakers in Oman can use these results to create specific incentives that encourage logistics companies to improve their BDAC. This would connect the use of technology directly to meeting green logistics standards and national sustainability goals. Additionally, the results show that Oman and other developing economies need to focus on both digital transformation and sustainability at the same time. BDAC is a chance for the whole country to work toward the goals of Oman Vision 2040, Oman Logistics Strategy 2040 (SOLS 2040), and Oman Net-Zero 2050. It also shows a desire to be competitive, be responsible for the environment, and grow the economy through knowledge. Based on this, the study identifies several policy levers that can support the development of BDAC for sustainability in the logistics sector in Oman. These levers can be linked to measurable triple-bottom-line (TBL) indicators, enabling policymakers to assess effectiveness rather than relying on ambitious targets. This includes the following:

- Training grants and workforce development programs in which its effectiveness can be evaluated using indicators such as fuel consumption per trip, declines in $CO_2$ emissions per ton-kilometer, and improvements in HSE incident rates.
- Data-sharing standards and integration procedures which can be in the form of frameworks, ready reporting templates for logistics analytics. This lever can be measured by using some indicators such as increased visibility, more regular emissions reporting, and improved safety checking across logistics networks.
- Green logistics incentives such as targeted tax relief, awards, loans, or better AI- Technology system support. The eligibility could be linked to proven reductions in fuel use or emissions, documented enhancement in safety performance.
- Enforcing Governance and ESG initiatives.
- Awareness programs on analytics and Data-Driven culture.

These policy levers emphasize capability development over technology deployment, reinforcing the study's core finding that sustainability value from BDAC depends on human, organizational, and

governance capacities. By linking interventions to measurable TBL indicators, policymakers can design support mechanisms that are both accountable and adaptive to evolving logistics system needs.

## 2. CONCLUSION

This qualitative study utilized a comprehensive four-theory framework, including the RBV, DCV, Technology-Organization-Environment (TOE), and the TAM, to examine how BDAC improve sustainability in Oman's logistics sector. Based on in-depth interviews with 25 senior managers from eight logistics companies, the study shows how BDAC is a unique and useful resource that helps companies find new opportunities, gain competitive advantages, and change their assets to meet new market needs and green logistics rules. BDAC makes sure that digital transformation has real, long-term benefits for both people and the environment by linking technological innovation with environmental responsibility.

As logistics continues to change around the world, Oman is a great example of how developing countries can use analytics, sustainability, and strategic decision-making to make systems that last. The findings make a big difference in the literature by breaking down the links between BDAC components like infrastructure, management, and personnel capabilities and sustainability performance in a developing economy. In addition to its theoretical implications, the study offers practical guidance for policymakers, logistics leaders, and organizational decision-makers aiming to execute data-driven sustainability initiatives and direct the sector towards more environmentally friendly operations, in accordance with Oman Vision 2040, the Sultanate of Oman Logistics Strategy 2040 (SOLS 2040), and the Net-Zero 2050 commitment.

## 3. LIMITATIONS AND FUTURE RESEARCH

Like any other studies, this research has several limitations that are important to keep in mind when interpreting its findings. First, the study was conducted in a single-country context, focusing specifically on the logistics sector in Oman. While this setting offers valuable insight into how BDAC supports sustainability in an emerging logistics economy, the findings are shaped by institutional, regulatory, and cultural conditions unique to that context. For this reason, care should be taken when applying the results to other countries, particularly where governance procedures, levels of digital maturity, or labour market conditions differ. That said, the study provides analytical insights that are likely to be relevant to other emerging economies with comparable structural characteristics.

Second, the study relies on a qualitative, interview-based research design. This approach allows for a deep exploration of capability structures and decision-making processes, but it necessarily emphasizes interpretation over statistical generalization. Although rigorous steps were taken to strengthen trustworthiness, including triangulation across roles and subsectors, systematic coding, and careful assessment of data saturation, the findings are grounded in participants' interpretations. As such, the study does not claim statistical generalization but instead aims for analytical overview.

Third, the analysis does not draw on objective or archival performance data, such as audited fuel consumption records, emissions inventories, or accident statistics. Therefore, sustainability outcomes are concluded from related practices, decision routines, and internally referenced KPIs rather than independently verified measures. While this interview-based evidence sheds light on how analytics is used and perceived to influence sustainability, future research could strengthen empirical validation by combining qualitative insights with longitudinal or quantitative performance data.

Ultimately, these limitations do not reduce the study's contribution but instead help define its scope. By making these boundaries explicit, the study clarifies how its findings should be interpreted and points to clear directions for future research, including comparative studies, mixed-method approaches, and multi-country designs that can extend and test the relationships identified here.

Building on this research, there are several promising directions for future research. First, future studies could aim for broader quantitative generalization, using large-scale surveys to determine whether the themes identified here hold true across a wider range of Omani logistics companies. Second, subsequent research could employ quantitative methods to test the proposed framework more rigorously. Finally, comparative

studies across other Gulf Cooperation Council (GCC) countries would be valuable, helping to uncover both regional similarities and differences in how BDAC influence sustainability.

### *3.1 Capability Roadmap*

Based on results, this study sets out a capability roadmap that reflects the Micro, Meso, Macro path through which BDAC supports sustainability in logistics. The underlying message is that sustainability gains are far more likely when people and organizational practices are in place before organizations commit to large-scale technology and system integration.

Phase 1: Micro level - Building personnel capability

The journey starts with people. Developing data literacy, analytical confidence, and sound decision-making skills across both managerial and operational roles is critical. The findings show that analytics only adds sustainability value when individuals can interpret dashboards, question data quality, and act on insights in their daily work. Without this foundation, even advanced analytics tools tend to be underused, and sustainability initiatives risk becoming little more than box-ticking exercises.

Phase 2: Meso level - Aligning governance and analytics practices

Once individual capability is established, the focus shifts to the organization as a whole. This phase involves putting clear governance in place such as defining data ownership, standardizing key performance indicators, and embedding analytics into usual decision practices. At the Meso level, governance turns individual insight into collective action, ensuring that sustainability analytics are reviewed consistently and translated into coordinated operational responses.

Phase 3: Macro level - Targeted infrastructure expansion

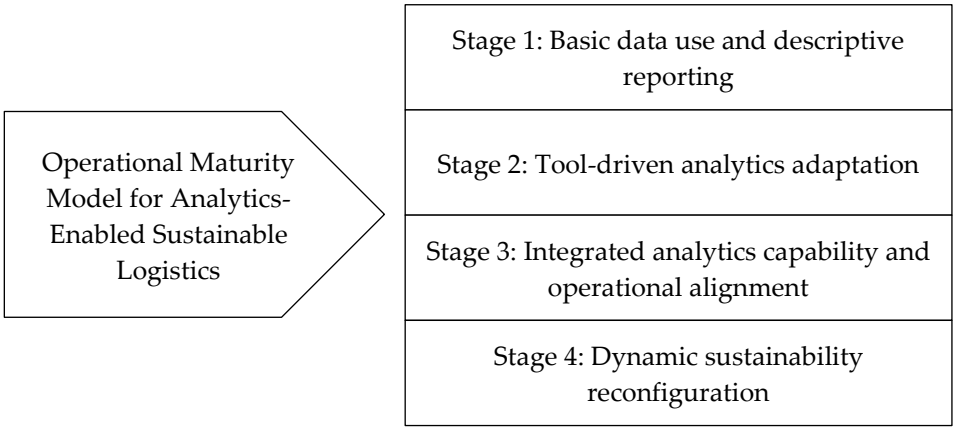
Only after the Micro and Meso level foundations are in place; it is possible to scale up analytics infrastructure. Here at the Macro level, actions include investments in telematics, system integration, and real-time analytics platforms. Accordingly, built on strong personnel capability and clear governance, these technologies are much more likely to deliver tangible sustainability outcomes, such as lower fuel consumption, reduced emissions intensity, and improved safety performance.

Phase 4: Reconfiguration and learning

Finally, BDAC should be treated as something that evolves rather than a single investment. In this regard, organizations need to regularly revisit and adjust individual skills, governance procedures, and system designs as sustainability priorities shift and operational complexity increases. At the end, this ongoing cycle of learning and reconfiguration helps keeping analytics capabilities relevant and aligned with sustainability objectives.

### *3.2 Operational maturity model*

The study also proposes an operational maturity model that explains how logistics organizations evolve from basic data use toward dynamic, sustainability-oriented analytics reconfiguration. The model conceptualizes maturity as a progressive capability trajectory, rather than a binary state of adoption.



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## Author Contributions

Conceptualization, S.A., N.-E.E., and M.A.-S.; methodology, N.-E.E. and M.A.-S.; validation, N.-E.E. and M.A.-S.; formal analysis, S.A.; resources, N.-E.E. and M.A.-S.; data curation, S.A.; writing—original draft preparation, S.A.; writing—review and editing, N.-E.E. and M.A.-S.; visualization, M.A.-S. All authors have read and agreed to the published version of the manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

## Data Availability Statement

Data are available from the authors upon request.

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