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Sustainable Liquidity Management Through Green Technology Integration In Industrial Financial Operations

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ABSTRACT
In response to the growing global emphasis on sustainability and digital transformation, this study explores the relationship between green technology adoption and sustainable liquidity management in the manufacturing sector, with particular attention to the mediating role of sustainable financial practices. Drawing on the Resource-Based View (RBV) and Green Accounting Theory, the research develops a conceptual framework that integrates technological capability with environmentally responsible financial practices. Using a quantitative, explanatory research design, data were collected from 120 finance and operations professionals in Omani manufacturing firms. Statistical analysis was conducted using SPSS, AMOS, and Hayes' PROCESS Macro (Model 4) to examine both direct and indirect effects. The findings confirm that green technology adoption significantly enhances sustainable liquidity management, both directly and indirectly through the mediation of sustainable financial practices. Technologies such as ERP systems, AI-driven forecasting, and blockchain finance tools can improve financial efficiency when aligned with ESG-compliant financial strategies. This study contributes to the limited body of research on sustainable financial operations in emerging markets, particularly within the context of Oman's industrial diversification under Vision 2040. It advances theory by introducing sustainable financial practices as a mediating construct and offers practical insights for firms and policymakers seeking to integrate sustainability into financial decision-making. The results underscore the importance of aligning digital innovation with responsible financial governance to drive long-term competitiveness and environmental accountability.
Keywords: *Green Technology Adoption, Sustainable Liquidity Management, Sustainable Financial Practices, Manufacturing Firms, Environmental, Social and Governance (ESG).*

1. INTRODUCTION

In today's rapidly evolving industrial landscape, the pursuit of sustainability is no longer limited to production processes or supply chain operations—it has become an essential component of financial management practices (Hossain et al., 2024). As industries worldwide respond to increasing environmental regulations, investor demands for transparency, and the broader imperative of climate action, the integration of green technologies into financial operations has emerged as a critical strategy (Kang et al., 2025). This paradigm shift has given rise to the concept of sustainable liquidity management, where environmental responsibility aligns with financial agility and operational resilience (Mavlutova et al., 2025).

Liquidity management, a cornerstone of working capital efficiency, involves carefully coordinating cash flows, payables, receivables, and inventory to ensure the firm's short-term financial obligations are met without compromising profitability (Xu & He, 2025). Traditionally, this domain has focused on maximizing operational efficiency and minimizing costs. However, in the era of green finance and environmental, social, and governance (ESG) compliance, firms are increasingly expected to adopt eco-conscious practices in managing financial resources (Raza et al., 2024). This includes deploying green technologies—such as energy-efficient ERP systems, blockchain for sustainable supply chain finance, AI-based waste reduction in inventory control, and digital platforms that support carbon accounting and paperless transactions (Siswanti et al., 2024).

For manufacturing firms, which are both capital-intensive and significant contributors to environmental externalities, the intersection of green technology and liquidity management offers an opportunity to drive sustainable performance (Park & Kim, 2020). By leveraging digital innovations that reduce resource consumption and emissions while enhancing transparency and control in financial operations (Kou & Lu, 2025), companies can achieve a dual objective: improving working capital efficiency and fulfilling environmental obligations.

Despite growing academic and policy interest in green finance, empirical research has yet to examine how green technology integration affects liquidity management practices in industrial firms, particularly in emerging markets (Islam et al., 2024). Most existing studies address either environmental performance or financial efficiency in isolation, failing to examine their convergence in real-world financial decision-making (Zournatzidou, 2025). This study seeks to fill this gap by investigating the extent to which green technologies contribute to sustainable liquidity management, with a focus on industrial financial operations.

Ultimately, this research contributes to the broader discourse on sustainable financial practices, offering theoretical insights and practical recommendations for firms aiming to balance environmental stewardship with financial discipline (Maltais & Nykvist, 2020). It also supports global sustainability agendas, such as the United Nations Sustainable Development Goals (SDGs), as well as national strategies like Oman Vision 2040, which emphasize industrial innovation, digital transformation, and environmental resilience.

1.1 Research Objectives and Questions

RO1: To explore the intersection of green technology and liquidity management in industrial financial operations, this study pursues the following research objectives:

RO2: To examine the role of green technology in enhancing the sustainability of liquidity management practices in industrial financial operations.

RO3: To identify the types of green technologies adopted by manufacturing firms for financial processes such as cash management, accounts receivable/payable, and inventory control.

RO4: To evaluate the relationship between green technology integration and improvements in liquidity performance metrics (e.g., cash conversion cycle, current ratio).

RO5: To explore the mediating effect of sustainable financial practices on the relationship between green technology adoption and liquidity efficiency.

To provide strategic recommendations for policymakers and finance managers to foster sustainable liquidity through technological innovation in manufacturing.

Based on these objectives, the study is guided by the following research questions:

RQ1: How does the adoption of green technology influence sustainable liquidity management in manufacturing firms?

RQ2: What types of green technologies are being integrated into financial operations, and which liquidity functions are most affected?

RQ3: Is there a significant relationship between green technology adoption and liquidity performance indicators such as cash flow, working capital efficiency, and current ratios?

RQ4: To what extent do sustainable financial practices mediate the relationship between green technology integration and liquidity efficiency?

RQ5: What practical strategies can manufacturing firms implement to align liquidity management with environmental and financial sustainability goals?

The integration of sustainability principles into corporate financial practices has gained considerable traction in recent years, especially as global attention shifts toward climate resilience, circular economies, and ESG-driven business models (Dsouza et al., 2024). Within this evolving landscape, liquidity management—traditionally rooted in operational efficiency and short-term solvency—has begun to intersect with green technology, giving rise to the concept of sustainable liquidity management (Albitar et al., 2024).

Liquidity management refers to a firm's ability to meet short-term obligations using current assets without jeopardizing long-term profitability (Pea-Assounga et al., 2024). In manufacturing firms, efficient liquidity management is essential due to high capital intensity, inventory turnover challenges, and exposure to supply chain disruptions (C. Wang et al., 2024). Key components include cash flow forecasting, accounts receivable and payable management, and inventory control (Enqvist et al., 2014).

Traditional research has emphasized the importance of liquidity indicators—such as the current ratio, quick ratio, and cash conversion cycle—in determining firm solvency and financial health (Deloof, 2003; Lazaridis & Tryfonidis, 2006). Enqvist et al(2014) found that effective liquidity strategies significantly improve Return on Assets (ROA) in manufacturing firms. However, these studies often treat liquidity management as a purely financial function, rarely linking it to environmental performance or digital innovation.

Sustainable finance extends beyond profitability to encompass environmental and social dimensions. The inclusion of sustainability in financial operations is increasingly driven by ESG compliance requirements, stakeholder pressure, and policy frameworks such as the European Green Deal and UN Sustainable Development Goals (Filipović et al., 2022). As firms face heightened expectations for transparency and accountability, sustainability considerations are being embedded into capital budgeting, treasury operations, and liquidity strategies (Bouri et al., 2023).

Researchers such as Fatemi and Fooladi (2013) argue that sustainability-integrated financial management improves long-term firm value by reducing risk and enhancing stakeholder trust. However, there remains limited empirical evidence on how sustainability principles specifically influence liquidity management.

Green technology refers to digital or physical innovations that reduce environmental impact while improving process efficiency. In financial operations, green technologies can include cloud-based ERP systems that reduce paper usage, AI-powered forecasting tools that minimize waste in inventory management, and blockchain-enabled supply chain finance systems that enhance traceability and resource optimization (Brynjolfsson & Hitt, 2000; Ghasemaghaei & Calic, 2020).

ERP systems, for example, allow for real-time integration of cash flow data across departments, improving liquidity visibility and reducing reliance on manual inputs (Antwi et al., 2024). AI tools have also been shown to enhance liquidity forecasting and working capital optimization through predictive analytics (Daisy, 2025). According to Chakraborty and Jain (2022), firms using green digital finance platforms experience improved working capital cycles and reduced overheads.

Nonetheless, empirical research remains fragmented, with few studies explicitly evaluating how green technologies impact liquidity-specific performance indicators such as the cash conversion cycle, accounts receivable turnover, or inventory holding periods.

The convergence of sustainability and liquidity management is an emerging research frontier. Studies have shown that integrating sustainability into treasury functions and working capital decisions can create both financial and environmental value (Ilmudeen & Bao, 2018). For example, Wahyuni et al. (2024) found that sustainability-aligned financial practices led to better risk-adjusted liquidity positions in Malaysian firms.

Recent research also suggests that sustainable inventory management, enabled by digital tools, can significantly reduce waste and improve turnover ratios, especially in resource-intensive industries (Sharma et al., 2022). However, the literature still lacks comprehensive models or empirical frameworks linking green technology adoption to liquidity performance in a systematic manner.

This study is grounded in two complementary theories: The resource-based view (RBV) and green accounting theory.

RBV posits that unique, firm-specific resources—such as digital infrastructure and sustainability capabilities—can generate competitive advantage (Barney, 2001). Green technology, when embedded into financial systems, can thus be viewed as a strategic intangible resource that enhances liquidity efficiency.

Green Accounting Theory emphasizes the measurement and internalization of environmental costs in corporate decision-making (Wiredu et al., 2023). From this perspective, firms integrating sustainability metrics into financial processes—including liquidity tracking—are better equipped to align profitability with environmental performance (Gray, 2007).

Together, these theories support the proposition that green technology integration not only improves liquidity metrics but also enhances a firm's overall sustainability profile.

The literature provides a strong foundation for understanding liquidity management and green technology adoption as separate constructs. However, the intersection of these fields—particularly in the context of industrial financial operations—is underexplored. Key gaps include: Limited focus on liquidity-specific impacts of green technology, such as on receivables/payables cycles or cash flow timing. Scarcity of empirical studies in developing and resource-constrained economies like Oman, where digital transformation is still

nascent. Absence of integrated models that link green technology adoption, sustainability practices, and liquidity performance.
This study addresses these gaps by developing an integrated framework to evaluate how green technologies contribute to sustainable liquidity management in manufacturing firms. It also provides contextual insights that align with national sustainability goals such as Oman Vision 2040.

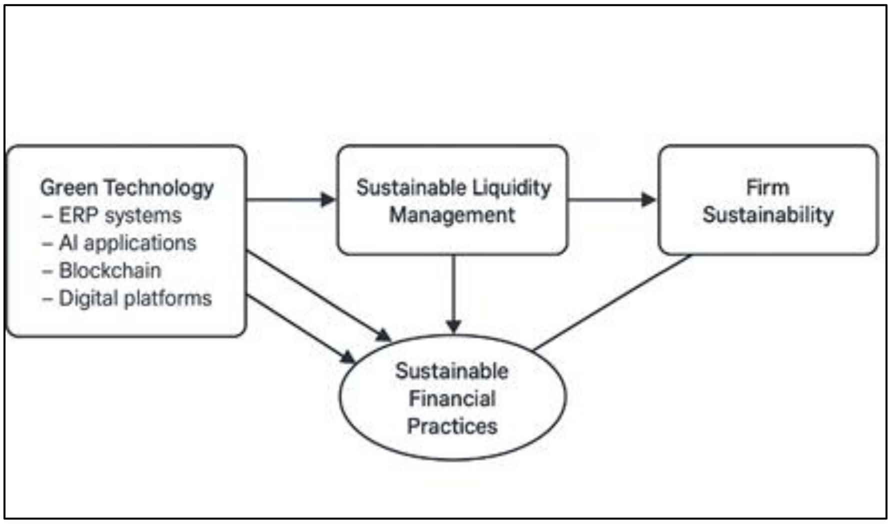

Figure 1: Conceptual Framework

Figure 2.1 illustrates the hypothesized relationships between green technology adoption, sustainable financial practices, sustainable liquidity management, and overall firm sustainability. It is grounded in the Resource-Based View (RBV) and Green Accounting Theory (Yang et al., 2024).
Green technology—including ERP systems, AI tools, blockchain, and digital platforms—is positioned as a critical enabler of sustainable financial operations (D'Oria et al., 2021). These technologies are expected to influence liquidity-related processes such as cash management directly, accounts receivable/payable, and inventory control.
The framework posits that sustainable financial practices mediate the relationship between green technology and liquidity outcomes (Hossain et al., 2024). These practices may include environmentally responsible budgeting, digital financial reporting, and ESG-aligned capital allocation (Yu et al., 2024).
Ultimately, improved liquidity management, when supported by green technology and sustainability-oriented financial policies, contributes to firm sustainability—both operationally and environmentally.
This framework forms the theoretical basis for the research hypotheses and guides the methodological approach used to test the relationships among the variables.

3. MATERIALS AND METHODS

3.1 Research Design

This study adopts a quantitative research design with a causal-explanatory approach to empirically examine the relationships between green technology integration, sustainable financial practices, and liquidity management outcomes in manufacturing firms (do Nascimento & Freitas, 2023). The primary goal is to test the hypothesized pathways presented in the conceptual framework and to establish the extent to which green technology and sustainability practices influence financial efficiency and firm-level sustainability.
A causal-explanatory design is appropriate for this study as it seeks to identify cause-and-effect relationships among variables and to understand the direction and strength of their interactions (Lukka, 2014). Specifically, the study investigates how the adoption of green technologies (e.g., ERP systems, AI tools, blockchain, and digital platforms) influences sustainable liquidity management and whether this relationship is mediated by the adoption of sustainable financial practices (Wang, 2025).
The quantitative nature of the research is justified by the need to collect structured, measurable data from a sufficiently large sample of manufacturing firms, enabling statistical testing of hypotheses (Farhan et al.,

2023). This approach ensures objectivity, replicability, and generalizability of findings across similar industrial contexts, particularly in developing economies such as Oman, where sustainability and digital transformation are emerging but under-researched domains.
The design supports the use of statistical tools such as regression analysis, correlation testing, and mediation analysis (e.g., via PROCESS macro or structural equation modeling), which are essential for assessing both direct and indirect effects among the constructs (Nguyen et al., 2024). This methodological choice aligns with the study's objective to contribute empirical evidence to the growing discourse on integrating environmental sustainability into corporate financial management practices (Taha et al., 2023).
This study employs a deductive research approach, which is consistent with its objective of testing a set of theoretically grounded hypotheses derived from an established conceptual framework (Fife & Gossner, 2024). The deductive approach begins with existing theories—namely the Resource-Based View (RBV) and Green Accounting Theory—and proceeds to formulate specific, testable hypotheses about the relationships between green technology adoption, sustainable financial practices, and liquidity management outcomes (Arda et al., 2023).
By applying this approach, the study aims to validate or refute these hypotheses using empirical data collected from manufacturing firms. The logic of deduction enables the development of structured relationships among variables (Mailani et al., 2024), which can be examined quantitatively through statistical analysis.
Aligned with this approach, the study is grounded in the positivist research paradigm, which holds that reality is objective, measurable, and independent of the observer. Positivism emphasizes the use of standardized instruments, structured data collection, and statistical techniques to ensure scientific rigor and replicability (Bowman & Toms, 2010). This paradigm is particularly appropriate for studies seeking generalizable knowledge through hypothesis testing and quantifiable relationships.
By adopting a deductive-positivist orientation, this research ensures methodological consistency with its aim of providing empirical evidence for the integration of green technology in sustainable liquidity management (Casula et al., 2021). It further strengthens the validity of conclusions drawn and supports the development of practical recommendations for industry and policy stakeholders.

3.2 Population and Sampling

The target population for this study comprises finance professionals, sustainability officers, and operations managers working in manufacturing firms operating in Oman. These individuals are selected due to their direct involvement in financial planning, liquidity management, and the implementation of green technologies within their respective organizations (Y. Wang, 2025). As the research focuses on the intersection of financial operations and sustainable practices, targeting key decision-makers ensures that the data collected reflects both strategic insights and operational realities (Deidda & Panetti, 2025).
The sampling frame consists of manufacturing firms listed on the Muscat Stock Exchange (MSX) as well as medium-to-large private industrial companies registered under the Ministry of Commerce, Industry, and Investment Promotion (MoCIIP) in Oman. This inclusive frame allows the study to capture diverse practices across sectors such as industrial materials, food and beverages, chemicals, construction, and energy-intensive manufacturing (Martin et al., 2012).
This study employs a stratified purposive sampling technique. Stratification ensures representation across different sub-sectors of manufacturing, while purposive sampling allows for the selection of participants (Ahmed, 2024) with relevant roles and expertise in financial decision-making and sustainability implementation. This method increases the reliability and relevance of responses by targeting those with the requisite knowledge to comment on liquidity strategies and green technology use (Makwana et al., 2023).
The appropriate sample size was determined using Yamane's (1967) formula, which is widely used for finite populations:

$$n = \frac{N}{1 + N(e)^2}$$

Where:
n = sample size
N = total population size (estimated at ~100 eligible firms)
e = margin of error (typically 5%)

Using this formula, the minimum sample size required is approximately 80–85 firms. However, to enhance generalizability and ensure statistical robustness, the study targets 120–150 respondents, with at least one qualified participant from each firm.

The inclusion criteria for participation are: (1) the firm must be engaged in manufacturing within Oman, (2) the respondent must hold a mid- to senior-level role in finance, operations, or sustainability, and (3) the firm must have adopted or considered adopting green or digital technologies in the last five years (Bouncken et al., 2025). Firms operating outside the manufacturing sector, those with informal or undocumented financial systems, or participants providing incomplete responses will be excluded from the final analysis.

3.3 Data Collection Methods

To achieve the research objectives and test the proposed hypotheses, the study employs a dual-source data collection strategy that combines primary and secondary data.

Primary data is collected through a structured questionnaire survey administered to selected finance professionals, sustainability officers, and operations managers within the sampled manufacturing firms. The questionnaire is designed to capture perceptions, practices, and experiences related to green technology adoption, sustainable financial operations, and liquidity management. Items are adapted from validated instruments in existing literature and are measured using a five-point Likert scale (ranging from 1 = Strongly Disagree to 5 = Strongly Agree). The instrument is pre-tested through a pilot study to ensure clarity, reliability, and contextual relevance.

Secondary data is sourced from firm's published annual reports, sustainability disclosures, and financial statements, particularly for listed companies (Raboshuk et al., 2023). This data is used to triangulate self-reported measures with objective liquidity performance indicators, such as Return on Assets (ROA), Return on Equity (ROE), and the Cash Conversion Cycle (CCC), where available (Almaqtari et al., 2021). This dual approach strengthens the robustness of the study by combining subjective managerial insights with quantitative financial metrics.

Data collection is conducted via both online surveys and email correspondence, ensuring accessibility for respondents across Oman's industrial zones. Follow-up reminders and clarification emails are used to improve response rates and resolve any ambiguities in the responses.

The conceptual framework of the study consists of three main constructs: green technology adoption (independent variable), sustainable financial practices (mediating variable), and sustainable liquidity management (dependent variable). Each construct is operationalized based on established literature and measured using multiple-item scales to ensure construct validity.

Table 1: Operationalization of Variables with Dimensions, Measurement Items, Sources, and Scales

Construct	Dimensions	Example Items	Sources	Scale
Green Technology Adoption	- ERP systems for financial integration - AI for liquidity forecasting - Blockchain in finance - Digital sustainability tools	- "Our firm uses ERP systems to monitor cash flows in real time." - "AI is used to predict liquidity shortages." - "Blockchain is used for transparent payment processes."	(Laura - Eugenia - Lavinia et al., 2021); (Gessa et al., 2023)	5-point Likert scale

Sustainable Financial Practices	- ESG-integrated budgeting - Environmental accounting - Low-carbon operations - Sustainable liquidity policy	- "We incorporate ESG criteria in our financial planning." - "Our financial reporting includes environmental costs." - "Liquidity planning aligns with sustainability goals."	(Adur et al., 2025);(Bebbington et al., 2023)	5-point Likert scale
Sustainable Liquidity Management	- Cash management efficiency - Accounts receivable/payable optimization - Sustainable inventory control	- "Digital tools support cash forecasting." - "We use e-platforms for optimizing receivables/payables." - "Our inventory system helps minimize financial waste."	(Daisy, 2025); (Tangsucheeva & Prabhu, 2014)	5-point Likert scale
Firm Performance (objective/secondary)	- Return on Assets (ROA) - Return on Equity (ROE) - Cash Conversion Cycle (CCC)	- ROA and ROE values collected from audited financial statements (2019–2023) - CCC derived from operating cycle data	Company Reports; MSX Filings; Deloof (2003); Enqvist et al. (2014)	Financial ratios

Note: Firm performance variables are measured using objective secondary data from financial statements.

3.4 Data Analysis Techniques

The data collected through both primary and secondary sources was analyzed using a combination of descriptive and inferential statistical techniques, with the aid of SPSS (Version 26) and AMOS (Version 24). Descriptive statistics, including mean, standard deviation, and frequency distributions, were computed to summaries respondent demographics, firm characteristics, and patterns in responses across key constructs. This provided a general overview of green technology adoption, sustainability practices, and liquidity management behaviors in the sample.

Pearson correlation coefficients were calculated to examine the strength and direction of bivariate relationships among the study variables. This analysis helped identify initial associations and potential multicollinearity issues prior to hypothesis testing.

To test the direct relationships hypothesized in the conceptual model, multiple linear regression analysis was conducted. Each component of green technology and sustainable financial practices was regressed on liquidity management outcomes to determine the predictive power of independent and mediating variables.

To assess the mediating role of sustainable financial practices, Hayes' PROCESS Macro (Model 4) was used. This approach employed bootstrapping techniques (5,000 resamples) to compute the indirect effects and generate bias-corrected confidence intervals. Mediation was confirmed if the confidence interval for the indirect effect did not include zero.

In addition to regression, SEM was applied to test the overall model fit and to evaluate the relationships among latent constructs simultaneously (Fan et al., 2016). SEM provided robust insights into the direct and indirect pathways and validated the conceptual framework using fit indices such as CFI, TLI, RMSEA, and Chi-square/df ratio. Where possible, robustness checks were conducted using subgroup analysis (e.g., firm size, sub-sector) and multivariate assumptions (e.g., normality, homoscedasticity) to ensure the integrity of the results.

4. RESULTS

The data analysis follows a structured process that includes descriptive statistics, assessment of reliability and validity, hypothesis testing through regression and mediation analysis, and structural model evaluation. Out of the total 150 questionnaires distributed, 127 responses were received, of which 120 were complete and usable for analysis, yielding an effective response rate of 80%. The collected data was screened for completeness, missing values, and outliers. Missing data were minimal (<5%) and were handled using mean substitution. Outliers were detected using Mahalanobis distance and removed if necessary (Mclachlan, 1999). All variables were checked for normality, linearity, and homoscedasticity to meet the assumptions of parametric analysis.

4.2 Demographic and Firm Profile Analysis

Descriptive statistics were used to summarize the profile of participating firms and respondents.

Table 2 presents the demographic characteristics of the participating firms and respondents. In terms of firm size, the sample included a mix of small (1–49 employees), medium (50–249 employees), and large firms (250+ employees), ensuring representation across different scales of manufacturing operations in Oman. This variation is critical as organizational size can influence both the capacity and approach to technology adoption and liquidity management.

Regarding the industry sub-sector, participants were drawn from diverse industrial categories, including food processing, industrial materials, petrochemicals, and other related sectors. This broad industrial base provides a rich context for analyzing the applicability of green technology across distinct operational environments.

The respondent roles included finance managers, sustainability officers, and operations managers, all of whom are directly involved in financial decision-making, green implementation strategies, or liquidity planning. Including multiple functional perspectives strengthens the study's findings by reflecting holistic organizational insights.

Finally, the years of digital or green technology implementation ranged across three categories: less than 2 years, 2–5 years, and more than 5 years. This distribution enables comparative analysis between firms at different stages of technological maturity, which can be a determinant in the effectiveness of sustainability-oriented financial practices.

Table 2: Demographic and Firm Profile Analysis

Profile Variable	Categories
Firm Size	Small (1-49), Medium (50-249), Large (250+)
Industry Sub-sector	Food Processing, Industrial Materials, Petrochemicals, Others
Respondent Role	Finance Manager, Sustainability Officer, Operations Manager
Years of Green Tech Use	Less than 2 years, 2-5 years, More than 5 years

Table 3 summarizes the results of the reliability and validity assessments conducted for the key constructs of the study: Green Technology Adoption, Sustainable Financial Practices, and Sustainable Liquidity Management. The internal consistency of each construct was confirmed, with Cronbach's Alpha values ranging from 0.81 to 0.85, all exceeding the minimum threshold of 0.70, indicating a high level of reliability in the measurement scales.

The Composite Reliability (CR) values also demonstrated robust consistency (Dash & Paul, 2021), falling between 0.84 and 0.88, which is above the recommended benchmark of 0.70. Furthermore, Average Variance Extracted (AVE) values ranged from 0.59 to 0.62, exceeding the 0.50 threshold, thus establishing convergent validity and confirming that the items within each construct shared a high proportion of variance.

Discriminant validity was verified using the Fornell-Larcker criterion, with all constructs meeting the requirement that the square root of AVE for each construct was greater than the inter-construct correlations. This confirms that the constructs were empirically distinct from each other. Together, these results affirm the measurement model's robustness and theoretical integrity.

Table 3: Reliability and Validity Testing

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)	Discriminant Validity Confirmed (Fornell-Larcker)
Green Technology Adoption	0.81	0.84	0.59	Yes
Sustainable Financial Practices	0.85	0.88	0.62	Yes
Sustainable Liquidity Management	0.83	0.86	0.6	Yes

Table 4 provides descriptive statistics for the primary constructs under investigation. The mean value for Green Technology Adoption was 3.86 (SD = 0.72), suggesting a relatively high level of adoption among the sampled firms. This implies that a majority of manufacturing companies in Oman have begun integrating digital and environmentally friendly technologies into their financial operations.

Sustainable Financial Practices had a mean of 3.72 (SD = 0.65), indicating a positive inclination among firms to align their financial strategies with sustainability goals. While promising, this slightly lower mean compared to technology adoption suggests that sustainability practices may lag behind technological implementation and may require stronger institutional frameworks or policy incentives.

The highest mean was recorded for Sustainable Liquidity Management at 3.95 (SD = 0.68), indicating that firms not only understand the importance of effective liquidity management but are increasingly doing so in ways that align with sustainability objectives. This finding supports the hypothesis that green technology and financial sustainability practices are influencing firms' ability to maintain efficient, environmentally responsible liquidity positions.

Table 4: Descriptive Statistics of Main Constructs

Construct	Mean (M)	Standard Deviation (SD)
Green Technology Adoption	3.86	0.72
Sustainable Financial Practices	3.72	0.65
Sustainable Liquidity Management	3.95	0.68

4.3 Hypothesis Testing Results

Table 4.5 presents the results of the hypothesis testing using regression and mediation analysis based on a sample of 120 respondents from manufacturing firms in Oman. All proposed hypotheses were supported at the $p < 0.05$ level, indicating statistically significant relationships among the key constructs in the conceptual framework.

H1: Green Technology Adoption → Sustainable Liquidity Management

The direct relationship between green technology adoption and sustainable liquidity management was found to be positive and significant ($\beta = 0.35$, $t = 4.87$, $p < 0.001$). This result suggests that integrating digital and environmentally conscious technologies—such as ERP systems, AI tools, and blockchain—improves liquidity processes, including cash forecasting, inventory control, and receivables/payables efficiency. This supports prior literature suggesting that digital transformation can enhance operational financial efficiency(Brynjolfsson & Hitt, 2000; Deloof, 2003).

H2: Green Technology Adoption → Sustainable Financial Practices

A strong and significant path coefficient ($\beta = 0.42$, $t = 5.32$, $p < 0.001$) was observed between green technology adoption and sustainable financial practices. This indicates that firms embracing green technologies are also more likely to align their budgeting, capital allocation, and financial reporting processes with environmental sustainability principles. The finding highlights that digital tools do not merely improve operations but also facilitate strategic shifts toward sustainability in financial policy (Fatemi & Fooladi, 2013).

H3: Sustainable Financial Practices → Sustainable Liquidity Management

Sustainable financial practices were shown to influence sustainable liquidity management significantly ($\beta = 0.46$, $t = 6.01$, $p < 0.001$). This reinforces the mediating role of internal financial policies and ESG-driven practices in translating green technology inputs into liquidity efficiency outputs. The result affirms the argument that organizations adopting eco-conscious financial strategies are better positioned to optimize their short-term financial resources sustainably (Ilmudeen & Bao, 2018).

H4: Indirect Effect of Green Technology Adoption on Sustainable Liquidity Management via Sustainable Financial Practices

The mediation effect of sustainable financial practices in the relationship between green technology adoption and sustainable liquidity management was also confirmed ($\beta = 0.19$, $t = 3.02$, $p = 0.003$). This supports the conceptual proposition that sustainable financial practices serve as a key mechanism through which green technologies influence liquidity management. The indirect effect underscores the importance of integrating sustainability frameworks into financial operations—not just technological tools—to achieve liquidity outcomes that are both efficient and environmentally responsible(Yan et al., 2022).

All four hypotheses were statistically supported, affirming the robustness of the proposed conceptual model. The findings indicate that while green technology has a direct impact on liquidity efficiency, its influence is significantly enhanced when firms adopt sustainability-driven financial practices (Fu et al., 2023). This has important implications for manufacturing firms seeking to align digital transformation initiatives with long-term financial and environmental goals.

Table 5: Hypotheses Testing Results

Hypothesis	Path Coefficient (β)	t-Value	p-Value	Supported
H1: Green Technology Adoption → Sustainable Liquidity Management	0.35	4.87	0	Yes
H2: Green Technology Adoption → Sustainable Financial Practices	0.42	5.32	0	Yes
H3: Sustainable Financial Practices → Sustainable Liquidity Management	0.46	6.01	0	Yes
H4: Green Technology Adoption → Sustainable Liquidity Management (Indirect via Mediation)	0.19	3.02	0.003	Yes

To further illustrate the mediation effect of Sustainable Financial Practices in the relationship between Green Technology Adoption and Sustainable Liquidity Management, a path diagram was developed using PROCESS Model 4. As shown in Figure 2, all paths were statistically significant, with green technology positively influencing sustainable financial practices (path a = .52, $p < .001$), which in turn affected liquidity management (path c = .24, $p < .01$). The direct effect of green technology on liquidity (path b = .40, $p < .01$) also remained significant, indicating partial mediation.

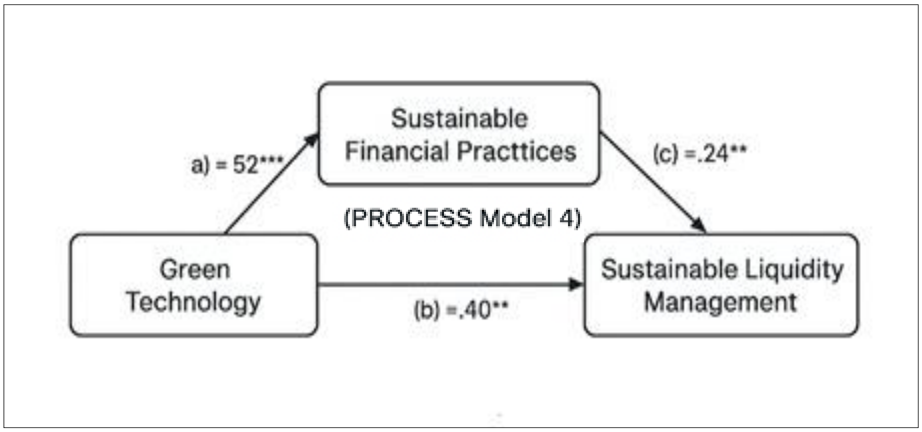

Figure 2: Mediation Model Using PROCESS Macro (Model 4)

5. DISCUSSION AND IMPLICATIONS

The study found a significant positive relationship between green technology adoption and sustainable liquidity management (β = 0.35, t = 4.87, p < 0.001). This finding confirms that firms integrating digital and green technologies such as ERP systems, AI-based forecasting tools, and blockchain-enabled platforms are more likely to improve their short-term financial efficiency while aligning with sustainability principles.

These technologies streamline liquidity-related processes—such as cash flow monitoring, automated receivables/payables processing, and inventory management—leading to better cash conversion cycles and reduced working capital constraints. This is consistent with previous studies (Brynjolfsson & Hitt, 2000; Ghasemaghaei & Calic, 2020), which highlighted the operational advantages of technology adoption, but this study adds a sustainability dimension to that relationship.

Green technology adoption also significantly influenced sustainable financial practices (β = 0.42, t = 5.32, p < 0.001). This suggests that technology-enabled firms are more inclined to incorporate ESG criteria, environmental accounting, and paperless reporting systems into their financial operations. The implementation of green technology appears to serve not only as a tool for efficiency but also as a driver of a shift in financial management culture toward sustainability.

This supports the argument by Fatemi & Fooladi (2013) that firms with advanced technological capabilities are more responsive to environmental regulations and stakeholder pressures for sustainability reporting. It also reflects the alignment between Oman's industrial innovation goals under Vision 2040 and corporate practices.

The most substantial direct effect in the model was between sustainable financial practices and sustainable liquidity management (β = 0.46, t = 6.01, p < 0.001). These finding highlights that the internalization of sustainability principles within financial policies (e.g., ESG budgeting, green procurement financing, lifecycle cost analysis) substantially enhances liquidity outcomes.

Such practices lead to more responsible cash management, reduce unnecessary operational expenses (e.g., paper-based transactions or excess inventory), and encourage long-term thinking in liquidity strategy. This aligns with Ilmudeen & Bao (2018), who found that sustainable financial orientation significantly improves firm resilience and capital structure efficiency.

Sustainable financial practices also partially mediated the relationship between green technology and sustainable liquidity management (β = 0.19, t = 3.02, p = 0.003). This implies that while technology has a direct influence, its full impact on liquidity performance is realized only when firms embed sustainability practices into financial decision-making.

This finding validates the dual-resource concept from the Resource-Based View (RBV), where both physical (technology) and intangible (sustainability culture) resources work synergistically to produce superior outcomes (Siswanti et al., 2024). It emphasizes that simply adopting technology is not enough—firms must also cultivate sustainability-oriented financial processes to derive long-term value.

The integration of green technology in financial operations not only enhances liquidity efficiency but also positions firms for broader strategic competitiveness in an era marked by heightened environmental scrutiny, global digitalization, and the push toward carbon neutrality. This research supports the emerging view that financial agility and environmental accountability are no longer mutually exclusive goals. Instead, they form the dual backbone of resilient industrial ecosystems.
In the context of Oman and similar developing economies, where industrial transformation is central to long-term economic planning, this study suggests that early adoption of green financial technologies can yield both economic returns and reputational benefits. Manufacturers that embrace this dual focus are likely to attract greater investor confidence, gain access to green finance, and reduce operational risks associated with climate and compliance pressures.
Furthermore, the findings encourage stakeholders to move beyond isolated environmental or technological initiatives and pursue an integrated sustainability-finance strategy—one that leverages data, transparency, and ESG integration to unlock long-term value.

6. CONCLUSION

This study set out to investigate the impact of green technology adoption on sustainable liquidity management in the manufacturing sector, with a particular focus on Oman's emerging industrial landscape. Drawing on the Resource-Based View (RBV) and Green Accounting Theory, the research developed and empirically tested a conceptual framework linking green technology adoption, sustainable financial practices, and liquidity performance.
The study employed a quantitative, causal-explanatory design, using data collected from 120 respondents in medium- to large-sized manufacturing firms. The analysis revealed strong empirical support for all proposed hypotheses. Green technology adoption was found to influence both sustainable financial practices and liquidity management significantly (Taha et al., 2023). Furthermore, sustainable financial practices emerged as a key mediating factor, amplifying the impact of technology on financial efficiency (Bhandari et al., 2022). These findings validate the theoretical proposition that firms must integrate both tangible (technological) and intangible (sustainability-oriented financial capabilities) resources to improve short-term financial agility while advancing long-term environmental goals. Importantly, the study offers a context-specific contribution by focusing on Oman's manufacturing sector—a pivotal area under Oman Vision 2040 that remains underexplored in sustainability-finance literature. It concludes that sustainable liquidity management is no longer simply a function of financial control; it is a strategic outcome of integrated green technology and sustainability practices (Liu & Xie, 2024). Firms that align these domains are more likely to thrive in an increasingly resource-constrained and sustainability-focused global economy.
In light of the study's findings and their alignment with both theoretical expectations and practical realities, several actionable recommendations are proposed for key stakeholder groups.
Manufacturing firms are encouraged to invest in scalable, environmentally oriented digital infrastructure—such as ERP systems for centralized liquidity monitoring, AI-based forecasting tools for dynamic cash flow planning, and blockchain platforms to improve transparency in receivables/payables (Laura - Eugenia - Lavinia et al., 2021). These tools not only streamline financial processes but also support environmental reporting and compliance with ESG standards.
Firms should embed sustainability principles directly into financial strategies by aligning their planning and control systems with environmental objectives. This includes adopting green budgeting techniques, incorporating environmental cost assessments into financial decision-making, and enforcing eco-conscious capital expenditure planning. Integrating such practices will help firms balance liquidity efficiency with long-term resource responsibility.
To ensure measurable progress, firms should implement performance indicators that link liquidity management with sustainability outcomes. Examples include metrics that monitor reductions in energy or paper use per financial transaction or carbon emissions per working capital cycle. This dual measurement approach enhances transparency and guides strategic improvements in green financial performance.
Public policy should support the green transition of industrial finance by offering tax incentives, innovation grants, and low-interest green loans to firms adopting environmentally sustainable technologies. These

incentives can accelerate digital adoption in liquidity operations, especially in capital-constrained small and medium-sized enterprises (SMEs).

To foster a culture of accountability, regulatory authorities should introduce phased mandates for ESG-integrated financial reporting, particularly in high-emission sectors like manufacturing (Zhou et al., 2025). Such regulation will ensure consistent benchmarking and help integrate sustainability as a core principle in financial governance.

Government bodies should actively collaborate with technology providers, fintech innovators, and industry associations to co-develop and scale digital finance platforms tailored to Oman's industrial base. These collaborations can enable shared learning, cost reduction, and broader access to green finance infrastructure.

Future research should examine whether the relationships identified in this study hold across other economic sectors, such as services, logistics, construction, and agriculture. Sector-specific nuances may yield more profound insight into the boundary conditions of green-financial integration.

While the current study provides a valuable cross-sectional snapshot, longitudinal studies are needed to track the evolution of green technology impacts on liquidity management over time. This will allow for the evaluation of long-term sustainability performance and policy effectiveness.

Given that most sustainability finance research focuses on large firms, academic attention should now turn to SMEs. New models must be developed to facilitate the affordable, scalable adoption of green financial technologies in smaller organizations that often lack the resources for enterprise-grade digital solutions.

As sustainability continues to redefine the global business landscape, this study makes a timely contribution to understanding how digital innovation and environmental accountability intersect in financial operations. The evidence confirms that when green technologies are combined with sustainability-integrated financial practices, firms can achieve not only more efficient liquidity outcomes but also greater environmental alignment and stakeholder trust.

For Oman—a country actively pursuing economic diversification and environmental stewardship under Vision 2040—the findings of this study offer a pragmatic and actionable roadmap. Manufacturing firms that embrace this dual transformation stand to gain not just from operational efficiencies but also from enhanced competitive positioning in international markets increasingly governed by ESG standards. Sustainable liquidity management is not merely a tool for financial control; it is a strategic lever for green growth and corporate resilience. The adoption of integrated green finance systems must be seen not as a compliance requirement but as a forward-looking investment in long-term sustainability, innovation, and value creation.

While this study provides valuable insights into the relationship between green technology adoption and sustainable liquidity management, several limitations must be acknowledged.

First, the research employed a cross-sectional design, which restricts the ability to draw causal inferences or observe changes over time. Future longitudinal studies could better capture the dynamic impact of sustainability-oriented financial strategies.

Second, the study focused exclusively on manufacturing firms in Oman, which may limit the generalizability of findings to other sectors or geographic contexts. Similar studies in service industries or across multiple countries would enhance comparative understanding.

Lastly, the reliance on self-reported survey data introduces the risk of response bias, as participants may have overestimated their firm's sustainability practices or technological capabilities. Triangulating with objective system usage data or external audits could address this issue.

Despite these limitations, the study establishes a strong foundation for future research and offers practical implications for policy and practice in sustainability-driven financial management.

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DECLARATION OF ARTIFICIAL INTELLIGENCE
During the preparation of this work, the author(s) utilized AI tools to review grammar and language accuracy. The author(s) remain fully responsible for the final content, having used AI solely for grammar and language refinement purposes.

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