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# Design Science Research for Enhancing Enterprise Resource Planning (ERP) Systems in Zimbabwe's Mining Industry: A Framework for Efficiency and Sustainability

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**ABSTRACT**

Enterprise Resource Planning (ERP) systems are crucial for optimising complex operations within Zimbabwe's vital mining industry. However, Zimbabwe's mining industry faces unique challenges, including infrastructure constraints, regulatory complexity, and sustainability imperatives that hinder the effectiveness of ERP systems. The study employs a rigorous Design Science Research (DSR) methodology, iteratively designing and evaluating an ERP enhancement framework. Through empirical fieldwork, including semi-structured interviews with twenty-five industry stakeholders and a structured questionnaire administered to one hundred and two mining professionals to validate qualitative findings and assess the framework's perceived utility, critical pain points were identified, which included fragmented data integration, inadequate real-time reporting, and poor alignment with Environmental, Social, Governance (ESG) goals. Research findings demonstrate that the framework significantly improves data accuracy, reduces operational latency, and enhances compliance with sustainability reporting. The framework proposes solutions including change management, data governance, technology integration, and performance metrics. Preliminary results suggest that a contextually relevant framework, informed by both managerial experience and broader industry perspectives, is crucial for realising the ERP system's full potential. This study delivers a validated, actionable framework to guide Zimbabwean mining companies towards enhanced operational efficiency, improved resource utilisation, and greater environmental and social sustainability. It also reinforces the applicability and rigour of DSR in addressing complex organisational problems, particularly in resource-intensive industries facing unique socio-economic circumstances.

**Keywords:** Design Science Research, Enterprise Resource Planning (ERP), Efficiency, Sustainability, Framework

## INTRODUCTION AND BACKGROUND

The mining sector is a crucial component of Zimbabwe's economy, contributing to the country's Gross Domestic Product (GDP) and serving as a key driver of economic growth (Nyikahadzoi et al., 2022). Besides the sector's contribution to the country's GDP and exports, it faces issues such as regulatory uncertainty, operational inefficiencies, and infrastructure deficits, which can hinder its full potential

(Mubonderi, 2023). In addition, Mlambo (2022) noted that debates about the mining's economic impacts often occur without a comprehensive understanding of its socio-economic contributions, a prevalent issue in Zimbabwe's discourse surrounding the sector. These discussions become critical when formulating policies aimed at enhancing the sector's sustainability while maximising its contributions to the national economy.

The mining sector in Zimbabwe has historically faced challenges such as outdated technology, inefficient processes, and resistance to change from employees, particularly middle management (Mahmood et al., 2019). In this dynamic environment, many mining companies in Zimbabwe have either partially implemented or are considering the adoption of ERP systems to streamline their operations. However, anecdotal evidence and preliminary observations suggest that the full benefits of these systems are often not realised. According to Larasati et al. (2023), the complexity of business operations in mining complicates the user's ability to adapt to new ERP systems, leading to difficulties in utilisation.

Common issues include a lack of precise strategic alignment, inadequate change management, and insufficient user training, often leading to systems that are not fully utilised or integrated (Larasati et al., 2023). Despite the promise of integration, disparate systems or poor data governance can result in fragmented information, hindering effective decision-making (Prasetya et al., 2023). Generic ERP solutions may not adequately address the specific operational nuances and regulatory requirements of the mining industry in Zimbabwe (Surjit, 2021). Existing ERP implementations may not sufficiently support the tracking and reporting of environmental impact, energy consumption, and adherence to sustainability standards (Svensson & Thoss, 2021). Technological infrastructure gaps, such as challenges related to reliable internet connectivity, power supply, and IT infrastructure, can impede the optimal performance of sophisticated ERP systems.(Surjit, 2021).

These challenges underscore the need for a systematic and rigorous approach to developing and enhancing ERP systems that are specifically designed to meet the unique demands of Zimbabwe's mining industry. DSR offers a suitable methodological paradigm for this endeavour, as it focuses on creating innovative solutions (artifacts) that are both theoretically grounded and practically applicable, thereby bridging the gap between academic research and real-world industrial needs. The enhancement of ERP systems within Zimbabwe's mining industry presents a significant opportunity to improve operational efficiency and ensure sustainability. This context requires a framework that not only addresses the technical demands of ERP implementations but also incorporates environmental and social dimensions inherent to the mining sector. This necessitates a tailored approach to ERP systems that considers the specific operational dynamics, regulatory environments, and environmental responsibilities prevalent in the mining industry. The study by West et al. (2024), highlights the need for customised ERP solutions to meet the variable demands and scale of operations. Such a tailored approach can improve data management and operational efficiency, thus benefiting the overall productivity of the sector.

Moreover, Nyikahadzoi et al. (2022) discuss the importance of corporate environmental responsibility within Zimbabwe's gold mining sector. As such, an ERP framework that incorporates sustainability metrics could significantly benefit the industry's operational models. In addition, the evaluation of critical success factors (CSFs) for ERP implementation provides valuable insights into user perspectives (Reitsma & Hilletofth, 2018). Identifying these factors is crucial for the effective deployment of ERP systems in mining companies, where user adoption and system customisability significantly influence operational outcomes. The research leverages DSR to develop a comprehensive framework that addresses these

critical gaps, ultimately enabling mining enterprises in Zimbabwe to leverage ERP systems for improved efficiency, enhanced decision-making, and sustainable growth.

## LITERATURE REVIEW

### Key concepts of Design Science Research

The DSR serves as a foundational methodology for developing ERP frameworks, specifically addressing the challenges presented by various industries, including mining. DSR fundamentally focuses on addressing significant and relevant organisational problems through the creation and evaluation of innovative artifacts (Hevner et al., 2004). The development process must be rigorous, grounded not only in practical utility but also in established kernel theories to ensure the framework is both technically sound and theoretically informed (March & Smith, 1995; March & Storey, 2008; Peffers et al., 2007). The artifact typically encompasses constructs which are definitions and concepts, models which are representations of processes or architecture, and methods which are guidelines for implementation or customisation, all aimed at resolving identified business or technical problems inherent in large-scale ERP endeavours.

ERP framework development via DSR is inherently iterative and evolutionary, not linear. It involves continuous cycles of building, that is, designing, prototyping framework components and rigorous evaluation within realistic contexts (Nunamaker et al., 1990). Evaluation is paramount and must assess the framework's utility, efficacy, and feasibility using methods appropriate to the development stage, such as technical experiments, for example, testing integration mechanisms, simulations, controlled case studies, or field testing in real organisational settings (Venable et al., 2016). Crucially, DSR emphasises that ERP frameworks cannot be developed in a vacuum; they are deeply embedded within, and must be evaluated against, specific organisational contexts. This includes factors like industry sector regulations, company size, existing legacy systems, and unique cultural or process requirements (Sein et al., 2011). The framework's design and evaluation must explicitly account for this context to ensure relevance and adaptability.

A core objective of DSR in ERP framework development is to generate meaningful and transferable knowledge contributions for both research and practice. Beyond simply creating a usable framework, the process aims to produce design knowledge, often formalised as design principles or theories (Gregor & Hevner, 2013). These principles abstract the essential learnings about why certain design features in the ERP framework work or do not work in specific contexts, providing actionable guidance for future implementations and contributing to the broader body of information systems knowledge (vom Brocke et al., 2020). For instance, developing an ERP framework for agile implementation might yield principles concerning modular configurability or stakeholder engagement strategies applicable beyond the initial case study (Johannesson & Perjons, 2014). Thus, the ultimate value lies not just in the artifact itself, but in the validated design knowledge it embodies, which informs both theoretical understanding of ERP systems and improves practical implementation methodologies.

### Application of DSR to ERP implementation

The DSR plays a pivotal role in developing frameworks for implementing ERP systems. This methodology emphasises the creation and evaluation of artefacts aimed at addressing pertinent problems within organisational contexts. Its systematic approach facilitates a comprehensive understanding of how ERP can align with business objectives and improve overall efficiency. One significant aspect of DSR is its structured process, which encompasses stages such as problem identification, design and development, demonstration, evaluation, and communication (Peffers et al., 2007). In addition, Peffers et al. (2007),

articulate these process steps, emphasising their relevance in creating a robust framework for ERP implementation. This systematic framework not only streamlines the design of ERP solutions but also enables iterative refinement based on evaluation findings, ensuring that implementations are both effective and aligned with user needs.

Further, the DSR encourages organisations to leverage various capabilities for effective digital transformations, which aligns with the DSR's objective of creating artifacts that enhance overall organisational performance by interlinking processes, people, and technology (Liutkevičienė et al., 2022). According to Badewi et al. (2018), a clear understanding of the efficiency, planning, and innovative benefits of ERP systems is crucial for organisational success. By utilising DSR, researchers and practitioners can delineate specific benefits and align them with organisational capabilities, thereby ensuring that the implemented systems contribute to broader strategic goals.

The emphasis on evaluation and continuous improvement in DSR methodology also addresses post-implementation challenges, which are often overlooked in many ERP projects. Furthermore, Saatçıoğlu (2009) stresses the importance of conducting post-implementation reviews to gather insights on user satisfaction and system effectiveness, thereby reinforcing the continuous learning aspect of DSR. This aspect is crucial, as it enables organisations to adapt their ERP systems to better meet user demands and respond to emerging challenges in real-time. The application of the DSR methodology in ERP system framework development is crucial for developing effective solutions that address both operational challenges and strategic objectives. By emphasising design, evaluation, and contextual relevance, DSR provides a comprehensive approach that can significantly enhance the chances of successful ERP implementations across varying organisational landscapes.

**Empirical insights and user engagement**

The application of DSR methodology in the context of ERP system implementation yields significant empirical insights and promotes user engagement. This methodology fosters a systematic approach to identifying, creating, and evaluating artefacts that directly address the needs and challenges faced by organisations during ERP implementations. Empirical insights were derived from real-world data and observations, providing a foundation for understanding the current state, identifying problems, and validating solutions. This research focused on the empirical insights into the specific realities of ERP systems in Zimbabwe's mining industry. The methods used to gather empirical insights included interviews and survey questionnaires.

An essential component of DSR methodology is its focus on iterative design and evaluation, emphasising the involvement of end-users as critical stakeholders. According to Sologia et al. (2024), quality information and user-friendly interfaces enhance user engagement and satisfaction, which is fundamental to the success of an ERP system. This insight underlines the importance of integrating user feedback in the design phase, ensuring that the ERP solutions developed cater specifically to user requirements and operational contexts. Engagement can further be augmented by understanding the dynamics between user satisfaction and engagement, as explored by (Rafsanjani et al., 2023), who propose a causal relationship between these two factors within ERP ecosystems. Additionally, effective user participation throughout the ERP implementation stages is crucial. The study by Gibbs (2014), discusses the importance of an integrated team approach, where user involvement is continually encouraged from the initial phases through to post-implementation, enhancing engagement and project commitment. This perspective aligns well with the principles of DSR methodology, where user feedback loops and engagement are integral to refining the ERP framework.

Furthermore, the concept of CSFs for ERP implementation, as examined by Reitsma & Hilletofth (2018), suggests that the user perspective must be foregrounded when assessing implementation success. They note that involving users highlights the nuanced, context-dependent factors that influence the effective adoption of ERP systems. This approach resonates with DSR methodology's emphasis on tailoring artifacts to meet precise operational demands and user requirements. Moreover, organisations are encouraged to continuously evaluate and adapt their ERP systems post-implementation. According to Abu Ghazaleh et al. (2019), internal organisational dynamics, including user interactions, greatly influence the sustainability and effectiveness of ERP implementations over time, emphasising that organisations should engage in ongoing evaluation and adaptation strategies that align with DSR methodology principles.

The empirical insights gained from applying the DSR methodology to ERP implementation underscore the importance of user engagement at every stage of the process. This methodological framework not only facilitates the creation of user-centred ERP systems but also ensures that ongoing user feedback is integrated into system enhancements, promoting a sustainable and effective user experience. The research on enhancing ERP systems in Zimbabwe's mining industry through DSR heavily relies on both empirical insights to understand the complex realities and user engagement to ensure the practical relevance, usability, and sustainable adoption of the proposed framework.

**Conceptual Framework**

A conceptual framework for enhancing ERP systems in Zimbabwe's mining industry using DSR focuses on developing an improved ERP system that addresses the specific needs of efficiency and sustainability within that context. The conceptual framework is structured around the iterative nature of DSR, influenced by contextual factors unique to Zimbabwe's mining sector. The framework begins with an input layer that captures the current challenges within the industry, existing ERP limitations, specific stakeholder needs, and relevant best practices and sustainability standards, including the ESG. These inputs are critically shaped by overarching contextual factors, such as Zimbabwe's mining regulations, economic volatility, existing infrastructure gaps, including power and connectivity, as well as escalating sustainability pressures related to water scarcity, energy demands, and community relations.

The core of the framework becomes the process layer, which meticulously follows the iterative DSR cycle (Peffers et al., 2007). This cycle comprises six sequential yet iterative steps: 1) problem identification and motivation, where the specific pain points and opportunities for improvement are defined; 2) objective definition, setting clear goals for both efficiency and sustainability; 3) artifact design and development, which involves creating the enhanced ERP system with dedicated modules for efficiency and sustainability; 4) demonstration, involving pilot deployment of the artifact in selected Zimbabwean mines; 5) evaluation, assessing the artifact's effectiveness using specific Key Performance Indicators (KPIs) for both efficiency and sustainability; and 6) communication & iteration, where findings are disseminated, and feedback informs further refinement, looping back to problem identification. The ultimate output layer of this framework is a robust, enhanced ERP system that is optimised for efficiency and integrated with sustainability considerations.

This system is expected to yield tangible outcomes, including improved operational efficiency, reduced environmental impact, enhanced social compliance, and the development of a scalable framework applicable to other mining operations. Figure 1 presents the proposed conceptual framework for enhancing ERP systems in Zimbabwe's mining industry. It leverages DSR principles to address the sector's unique challenges, thereby fostering efficiency and sustainability. By focusing on artifact creation, stakeholder

engagement, and addressing technological infrastructure issues, the framework aims to yield solutions that are both theoretically sound and pragmatically effective.

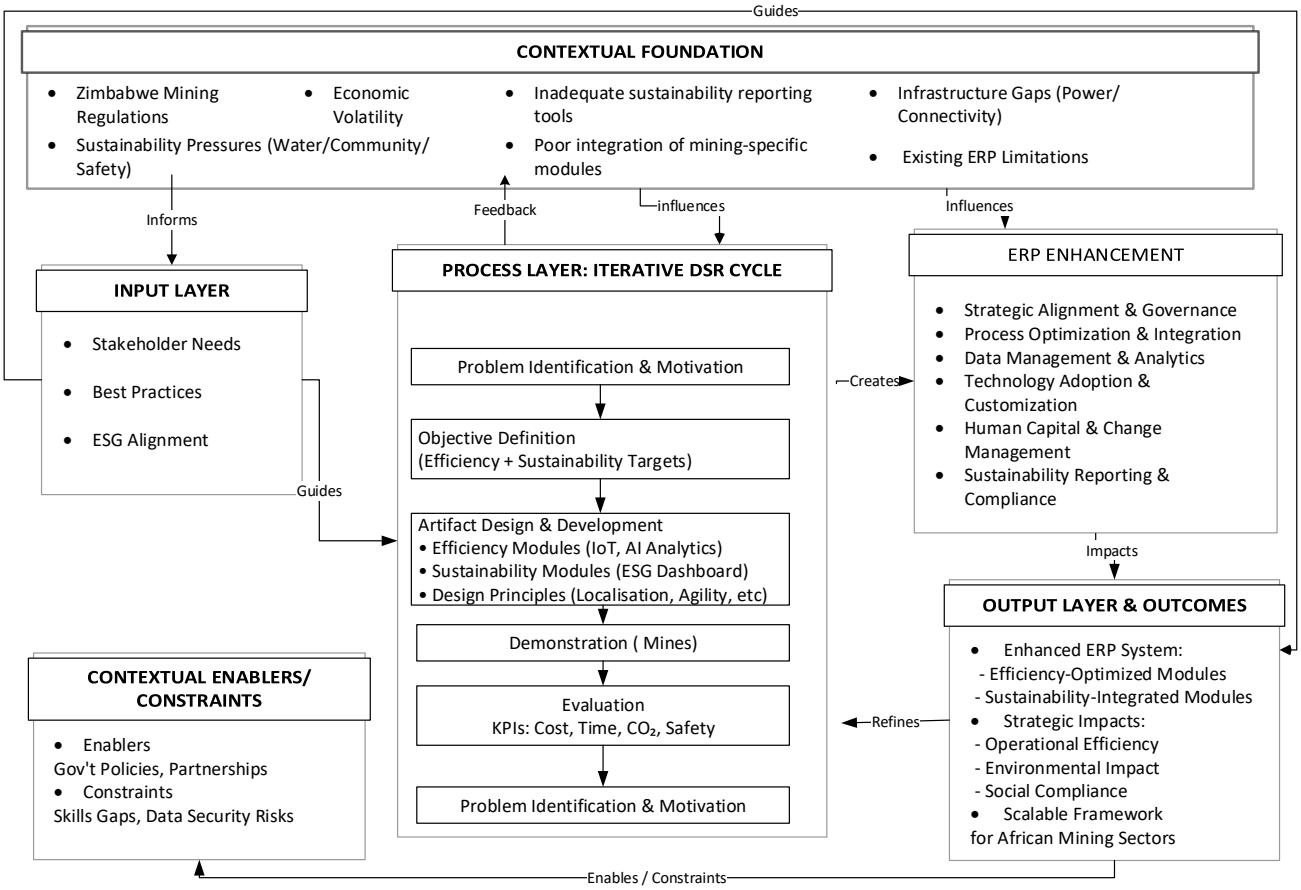


**Figure 1: A Proposed ERP Framework for Efficiency and Sustainability**

## METHODS AND MATERIALS

### Research Philosophy

The study adopted a DSR methodology to create and validate a practical framework for ERP enhancement. The iterative cycles included problem analysis of the literature on DSR, ERP implementation and the Zimbabwean mining sector context, framework development, and rigorous validation with stakeholders.

### Research Design

The study employed a mixed-methods research design, specifically a concurrent triangulation approach, integrating both qualitative and quantitative data collection and analysis. This design aligned with the iterative and evaluative nature of DSR, allowing for a comprehensive validation of the developed artifact, that is, the framework.

### Population and Sampling

The target population comprised professionals within Zimbabwe's mining industry involved in ERP systems, operations, IT, and management. For the qualitative sample, A semi-structured interview was conducted with twenty-five (25) industry professionals selected using purposive sampling. Questions focused on current ERP challenges, perceived benefits of the proposed framework, and specific feedback on its components related to efficiency and sustainability were asked. Participants included IT managers, operational heads, ERP consultants, and ERP users chosen for their in-depth knowledge and experience.

As for the quantitative sample, one hundred and two (102) responses were received from the online survey questionnaire submitted to different ICT professionals, aiming for a broader representation of personnel involved with or impacted by ERP systems. The survey questionnaire included Likert-scale items to assess the framework's perceived relevance, usability, and effectiveness in addressing efficiency and sustainability goals, along with open-ended questions for additional qualitative insights.

**Validity and Reliability**

The author ensured content validity by developing the interview guide based on extensive literature to ensure comprehensive coverage of the research objective. To ensure Construct Validity, the instruments were designed to measure the theoretical constructs of ERP enhancement, efficiency, and sustainability as defined within the framework. As for reliability, the internal consistency was analysed using Cronbach's Alpha for the quantitative instrument. The author also used triangulation, where both qualitative (interviews) and quantitative (questionnaires) data collection methods were combined with insights from the DSR process itself to enhance the overall validity and reliability of the findings.

**Statistical Treatment of Data**

The qualitative data from interview transcripts and open-ended questionnaire responses were analysed using thematic analysis. This involves identifying recurring themes, patterns, and insights related to the framework's strengths, weaknesses, and areas for improvement. The quantitative data from questionnaire responses were analysed using descriptive statistics to summarise perceptions and inferential statistics to explore relationships between variables, such as the perceived impact of specific framework components on efficiency or sustainability.

**Ethical Considerations**

The research adhered to strict ethical guidelines where all participants provided informed consent, understanding the research purpose, their voluntary participation, and their right to withdraw. Anonymity and confidentiality were ensured by keeping participant identities and specific organisational details anonymous and confidential. Data was de-identified to prevent attribution. Collected data was stored securely and accessed only by the research team. Lastly, the author ensured beneficence and non-maleficence, where the research aimed to benefit the Zimbabwean mining industry without causing harm to participants or organisations.

## RESULTS, FINDINGS AND DISCUSSION

### RESULTS FROM DATA COLLECTION

This subsection presents the key results derived from the semi-structured interviews and the survey questionnaire.

**Semi-structured Interviews**

Interviews were conducted with 25 key stakeholders from various mining operations across Zimbabwe, including coal, chrome, gold, platinum, and diamond mines. The interviewees held diverse roles, and the demographic characteristics of the participants are summarised in Table 1.

**Table 1: Demographic profile of interview participants**

| Number of Participants | Role/Designation | Female | Male | Years of Experience in Mining ERP |
|---|---|---|---|---|
| 1 | ICT | 4 | 5 | >10 |

| | | | | |
|---|---|---|---|---|
| 2 | Finance / Accounts | 7 | 4 | >5 |
| 3 | Sustainability Officers | 2 | 1 | >6 |
| 4 | Legal Officers | 1 | 1 | >5 |

As shown in Table 1, participants' gender was taken into account to minimise potential gender bias. Also, the interview participants held key positions within their respective departments. Their experience with ERP systems in the mining sector averaged over 5 years. This experience level suggests a deep understanding of the ERP system landscape and the challenges and opportunities within the Zimbabwean mining context. Thematic analysis of the interview transcripts revealed several recurring themes:

**Challenges with Current ERP Systems**

A pervasive theme was the lack of customisation for local mining operations. Interviewees frequently cited generic ERP modules that failed to account for unique Zimbabwean mining practices, geological variations, and local reporting requirements. Inadequate modules for ESG tracking emerged as a critical deficiency. Mines struggled to accurately monitor water usage, energy consumption, carbon emissions, and community development initiatives within their existing ERP setups, often resorting to manual, disparate systems. Poor integration with existing systems and infrastructure constraints was a significant hurdle. Intermittent internet connectivity and unreliable power supply in remote mining areas were repeatedly mentioned as barriers to real-time data synchronisation and system reliability.

**Stakeholder Needs**

A strong demand for real-time data to enhance operational efficiency was evident from the interviewees' responses. The respondents from finance emphasised the need for immediate insights into equipment performance, production metrics, and supply chain visibility to optimise operations and reduce downtime. Sustainability reporting capabilities were highlighted as crucial, driven by increasing regulatory scrutiny and corporate social responsibility initiatives. Specific needs included the accurate tracking of water usage, energy consumption, and carbon footprint, as well as comprehensive documentation of community development projects. Respondents from ICT indicated that user-friendly interfaces and training tailored to diverse skill levels were essential for successful ERP adoption, particularly given the varying levels of digital literacy among operational staff.

**Contextual Factors**

Regulatory pressures, particularly compliance with the Zimbabwe Environmental Management Agency (EMA) regulations, were a constant concern. Interviewees expressed a need for an ERP system that simplifies and automates the process of generating EMA-compliant reports. Economic volatility, including frequent currency fluctuations, significantly impacted procurement, costing, and financial planning, underscoring the need for adaptable financial modules within an ERP. Infrastructure gaps, specifically unreliable power supply and internet connectivity, were confirmed as critical environmental constraints that impact the feasibility of entirely cloud-based or real-time-dependent ERP solutions.

**Survey Questionnaire (102 respondents)**

The survey questionnaire was distributed to 102 respondents across various mining operations in Zimbabwe. The demographic profile consisted of 46.1% Females and 53.9% males, with 42% from ICT, 19.6% from legal, 28.24% from Finance, and 9.8% from Sustainability. Respondents represented a diverse mix of experiences with ERP systems and varied educational backgrounds.

**Table 2: Demographic Profile from Survey Questionnaire**

| | | Count | Column N % |
|---|---|---|---|
| Gender | Female | 47 | 46.1% |
| | Male | 55 | 53.9% |
| Profession | ICT | 43 | 42.2% |
| | Legal | 20 | 19.6% |
| | Finance | 29 | 28.4% |
| | Sustainability | 10 | 9.8% |
| Level of Education | Secondary Level | 2 | 2.0% |
| | National Certificate level | 18 | 17.6% |
| | Diploma level | 41 | 40.2% |
| | University level | 41 | 40.2% |
| Experience with ERP | 0-10 Years | 24 | 23.5% |
| | 11-20 Years | 48 | 47.1% |
| | 21-30 Years | 25 | 24.5% |
| | 31 Years + | 5 | 4.9% |

**Reliability Analysis**

The authors used Cronbach's alpha to assess the internal consistency reliability of a set of survey questionnaire items. This effectively assessed the overall degree of relatedness among the elements, as shown in Table 3.

**Table 3: Reliability Analysis**

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .842 | 51 |

An alpha rating of 0.842, shown in Table 3, is generally regarded as good. The results indicate that the questionnaire items possess a high level of internal consistency, suggesting that ERP implementation using DSR to promote efficiency and sustainability can be accurately measured.

**Current ERP Limitations**:

The respondents noted the current challenges affecting ERP system implementation. Table 4 presents the questionnaire responses to current ERP system limitations.

**Table 4: Current ERP System Limitations**

| | | Count | Column N % |
|---|---|---|---|
| Inadequate Sustainability Tracking | Strongly Disagree | 0 | 0.0% |
| | Disagree | 0 | 0.0% |
| | Neutral | 3 | 2.9% |
| | Agree | 67 | 65.7% |

| | | | |
|---|---|---|---|
| | Strongly Agree | 32 | 31.4% |
| Insufficient adaptation to local regulatory changes | Strongly Disagree | 0 | 0.0% |
| | Disagree | 0 | 0.0% |
| | Neutral | 1 | 1.0% |
| | Agree | 64 | 62.7% |
| | Strongly Agree | 37 | 36.3% |
| ERP systems exhibited poor integration | Strongly Disagree | 0 | 0.0% |
| | Disagree | 0 | 0.0% |
| | Neutral | 5 | 4.9% |
| | Agree | 52 | 51.0% |
| | Strongly Agree | 45 | 44.1% |

It was noted that 65.7% of respondents agreed and 31.4% strongly agreed that their existing ERP systems do not adequately support comprehensive sustainability tracking, highlighting a significant functional gap. Additionally, 62.7% agreed and 36.3% strongly agreed that their current ERP systems were not sufficiently adaptable to local regulatory changes, necessitating manual adjustments and external reporting processes. Furthermore, 51% agreed and 44.1% strongly agreed that their ERP systems exhibited poor integration with other operational technologies, such as SCADA and IoT sensors, resulting in data silos.

**Stakeholder Needs and Priorities**

The respondents noted the Stakeholder Needs and Priorities as given in Table 5.

**Table 5: Stakeholder Needs and Priorities**

**Statistics**

| | | Operational efficiency | Sustainability modules | User-friendliness and ease of training | Cost-effectiveness |
|---|---|---|---|---|---|
| N | Valid | 102 | 102 | 102 | 102 |
| | Missing | 0 | 0 | 0 | 0 |
| Mean | | 4.32 | 4.28 | 4.35 | 4.39 |

It was noted that the participants consistently prioritised features that enhance efficiency and sustainability, as shown in Table 5. The mean rating for operational efficiency features, for example, real-time monitoring and production planning, was 4.32/5. This effectively means that respondents strongly agreed that operational efficiency is needed from the ERP system. Additionally, the participants strongly agreed that there should be sustainability modules, such as ESG reporting and resource tracking, as demonstrated by a mean rating of 4.28/5. The respondents also strongly agreed that user-friendliness and ease of training must be given priority in ERP systems, as demonstrated by the mean rating of 4.35/5. Moreover, the participants also strongly agreed that cost-effectiveness would be critical for ERP implementation, as shown by a mean rating of 4.39/5.

**Perceived Importance of Design Principles**

The respondents noted the perceived importance of the design principles outlined in Table 6.

**Table 6: Perceived Importance of Design Principles**

| | | Count | Column N % |
|---|---|---|---|
| Localisation | Strongly Disagree | 0 | 0.0% |
| | Disagree | 1 | 1.0% |
| | Neutral | 5 | 4.9% |
| | Agree | 66 | 64.7% |
| | Strongly Agree | 30 | 29.4% |
| Triple Bottom Line | Strongly Disagree | 0 | 0.0% |
| | Disagree | 0 | 0.0% |
| | Neutral | 2 | 2.0% |
| | Agree | 63 | 61.8% |
| | Strongly Agree | 37 | 36.3% |
| Agility | Strongly Disagree | 0 | 0.0% |
| | Disagree | 0 | 0.0% |
| | Neutral | 1 | 1.0% |
| | Agree | 59 | 57.8% |
| | Strongly Agree | 42 | 41.2% |

The insights from the survey questionnaire highlighted strong agreement on the importance of the proposed design principles for a new ERP system. It was noted that in terms of localisation, 64.7% of respondents agreed and 29.4% strongly agreed that local adaptation, including multi-currency support and integration with local regulatory frameworks, is critical. In terms of the Triple Bottom Line, 61.8% agreed and 36.3% strongly agreed that the ERP should support tracking of economic, environmental, and social performance. In addition, in terms of agility, 57.8% agreed and 41.2% strongly agreed on the necessity for the ERP system to be flexible and adaptable to evolving business needs and market conditions.

## FINDINGS: INTEGRATION WITH THE FRAMEWORK

This subsection interprets the quantitative and qualitative results within the context of the proposed conceptual framework, illustrating how the empirical data validates and informs its various components.

**Input Layer Validation**

The comprehensive results from both the interviews and the survey unequivocally validated the components of the input layer. The consistently identified ‘challenges with current ERP systems’, for example, lack of customisation, inadequate ESG modules, poor integration, directly formed the foundation for defining the industry challenges and existing ERP limitations within the framework. Furthermore, the detailed stakeholder needs, such as real-time data, sustainability reporting, and user-friendliness, are clearly articulated in the 'Stakeholder Needs' component, providing a data-driven basis for prioritising design features. The high percentage of respondents, 64.7% of respondents agreed and 29.4% strongly agreed for localisation, 61.8% agreed and 36.3% strongly agreed for Triple Bottom Line,

and 57.8% agreed and 41.2% strongly agreed for agility, emphasising sustainability and local adaptation, underscores the critical importance of these specific Best Practices as core inputs.

**Contextual Factors' Pervasive Influence**

The data strongly confirmed the significant and pervasive influence of Zimbabwe's unique contextual factors. Interviewees' consistent mention of regulatory pressures, for example, EMA compliance, economic volatility, such as currency fluctuations, and infrastructure gaps, for instance, unreliable power and internet, was quantitatively supported by the survey, where 59.8% of respondents agreed and 37.3% strongly agreed to cited economic volatility and 65.7% agreed and 34.3% strongly agreed to mention infrastructure gaps as major operational challenges. This empirical evidence validates the framework's depiction of contextual factors as an overarching influence on all layers, emphasising their role in shaping problem definition, artifact design, and implementation strategies.

**Design Principles as Core Pillars**

The high level of agreement, that is, 64.7% of respondents agreed and 29.4% strongly agreed for localisation, 61.8% agreed and 36.3% strongly agreed for Triple Bottom Line, and 57.8% agreed and 41.2% strongly agreed for agility on the importance of the Key Design Principles of Localisation, Triple Bottom Line and Agility in the survey findings firmly establishes their centrality within the framework. The qualitative insights from interviews further elucidated how these principles should be manifested in the ERP artifact, for instance, Localisation implying multi-currency support and local language interfaces, and Agility fostering modular development for quick adaptation. This strong validation confirms their critical role, particularly within the Artifact Design & Development step of the DSR cycle.

**Validation of the Process Layer (DSR Cycle)**

The iterative nature of the Process Layer (DSR Cycle) was implicitly validated by the feedback from participants. During the semi-structured interviews, several experts emphasised the necessity of a flexible development process, including pilot testing and iterative refinements, to ensure the ERP system truly adapts to the dynamic and often unpredictable mining environment. This sentiment aligns perfectly with the continuous feedback loops inherent in the DSR methodology, for example, from communication and iteration back to problem identification, underscoring its suitability for this research context.

**Alignment with Desired Output Layer Outcomes**

The empirical data strongly supported the desired outcomes articulated in the Output Layer. The survey results, with 90% of respondents believing that an ERP system integrating efficiency and sustainability would significantly improve their operations, directly corroborated the framework's ultimate goals of achieving improved operational efficiency, reduced environmental impact, and enhanced social compliance. This provides a clear mandate for the development and implementation of the enhanced ERP system as the core output.

## DISCUSSION

This subsection delves into the implications of the findings, the contributions of the proposed framework, and its alignment with existing theoretical and practical considerations.

**Addressing the Research Problem**

The findings provide compelling evidence that the proposed DSR-based framework directly addresses the pressing research problem of enhancing ERP systems for efficiency and sustainability in Zimbabwe's mining industry. The articulated challenges, for example, inadequate ESG tracking and poor customisation, are precisely what the framework seeks to resolve through its structured process. The

integration of dedicated efficiency and sustainability modules within the ERP artifact, guided by the DSR cycle, is a direct, data-driven response to the needs expressed by a significant majority of respondents. This ensures that the developed solution is not a generic ERP implementation but a tailored system capable of navigating the unique operational and contextual landscape of Zimbabwean mining.

**Theoretical Contributions**

This research makes significant theoretical contributions, primarily by extending the application of DSR. While DSR has been widely applied in Information Systems, its specific application in the context of integrating efficiency and sustainability into ERP systems within the unique socio-economic and infrastructural landscape of a developing nation's mining industry, like Zimbabwe, is novel. The framework demonstrates how DSR can be effectively utilised to create context-specific IT artifacts that simultaneously optimise economic performance and foster responsible environmental and social practices. Furthermore, this study contributes to the broader ERP literature by empirically underscoring the critical need for localisation and agility in ERP implementations, particularly in volatile and resource-constrained environments. Traditional ERP deployments often assume stable environments, but our findings highlight that these design principles are not merely desirable but essential for successful ERP adoption and value creation in dynamic contexts. The explicit inclusion and validation of the 'Triple Bottom Line' as a core design principle within an ERP development framework also enriches the existing body of knowledge on sustainable information systems.

**Practical Implications**

The proposed framework offers substantial practical implications for various stakeholders. For ERP vendors, it provides a structured, evidence-based roadmap for developing systems that genuinely meet the nuanced demands of the Zimbabwean mining sector, moving beyond off-the-shelf solutions. For mining companies in Zimbabwe, the framework offers a systematic approach to identifying their ERP needs, evaluating potential solutions, and guiding implementation, thereby mitigating risks associated with large-scale IT projects. The emphasis on the 'Demonstration' (pilot testing) step within the DSR cycle is particularly crucial for practical application, as it allows for real-world adaptation and refinement before full-scale deployment, a critical factor given the infrastructure gaps and economic volatility in Zimbabwe. This iterative piloting ensures that the final enhanced ERP system is robust, user-accepted, and truly fit-for-purpose.

**Validation of the Framework**

The mixed-methods approach employed in this research provided robust validation for the proposed framework. The quantitative results from the survey statistically supported the critical components of the framework, including the importance of sustainability modules and key design principles. Concurrently, the qualitative insights garnered from the semi-structured interviews offered rich, contextual depth, explaining *why* particular challenges exist and *how* specific needs manifest within Zimbabwean mining operations. This triangulation of data sources strengthened the credibility and generalisability of the findings, demonstrating that the framework is not only conceptually sound but also empirically grounded in the realities of the industry. The alignment between the identified Input Layer and the desired Output Layer further validates the framework's logical coherence and problem-solving capability.

## CONCLUSION

The results from both the interviews and the survey strongly supported the need for an enhanced ERP framework that addresses efficiency and sustainability in Zimbabwe's mining sector. The proposed

framework, grounded in DSR and validated by stakeholders, offers a structured approach to developing such a system. The framework addresses the critical challenge of optimising ERP systems within Zimbabwe's uniquely demanding mining industry. The core contribution was the development and articulation of a comprehensive DSR Framework for enhanced ERP systems in Zimbabwean Mining, meticulously designed to bridge the gap between generic ERP functionalities and the specific operational, regulatory, and sustainability imperatives of the sector. The framework's efficacy lies in its multifaceted design, built upon foundational design principles that prioritise contextual adaptability, scalability, modularity, resilience, sustainability by design, and stringent regulatory compliance to ensure solutions are inherently fit-for-purpose, robust, and aligned with local and global expectations. These principles ensure that any ERP enhancement is not merely technological but deeply rooted in the operational realities and regulatory landscape of Zimbabwean mining.

Furthermore, these principles directly inform the core enhancement modules, which are adaptable configuration blueprints, an integrated sustainability metrics dashboard, and a context-sensitive analytics engine designed to drive tangible improvements. The adaptable configuration blueprints provide tailored process optimisation, while the integrated sustainability metrics dashboard offers a critical tool for tracking environmental, social, and economic key performance indicators, fostering genuine sustainability. The context-sensitive analytics engine ensures that data-driven insights are relevant and actionable, empowering better decision-making. These collectively transform standard ERP into a powerful, mining-specific tool capable of optimising core processes while rigorously tracking and managing environmental, social, and economic performance.

The successful adoption and longevity of the enhanced ERP systems are supported by the implementation and governance enablers, including a phased implementation playbook, a stakeholder engagement protocol, a continuous performance monitoring and improvement loop, and a robust data governance model. The phased implementation playbook provides a structured roadmap, the stakeholder engagement protocol ensures buy-in and relevance, the performance monitoring and improvement loop embeds continuous enhancement, and the data governance model guarantees data integrity and trust. These elements collectively lay the groundwork for a smooth transition and ongoing optimisation. Moreover, the integration of cross-cutting elements – localisation, training and capacity building, and technology agnosticism – ensures the framework is not merely technically sound but also culturally resonant, human-centric, and adaptable to Zimbabwe's evolving technological landscape. These elements underscore the framework's practical applicability and future-readiness.

In essence, this DSR framework provides a scientifically grounded and practically relevant blueprint for transforming ERP systems in Zimbabwe's mining industry. By integrating efficiency, sustainability, and adaptability, it offers a pathway for mining organisations to not only streamline their operations but also contribute meaningfully to the nation's economic growth and environmental stewardship. It empowers mining enterprises to navigate local complexities, meet stringent regulatory requirements, optimize resource utilization, minimize environmental and social impacts, and ultimately contribute more effectively to Zimbabwe's economic development. The successful application of this framework promises not only improved organisational performance for individual mines but also a more responsible, efficient, and sustainable future for the Zimbabwean mining sector as a whole.

While this research provides a valuable contribution, its scope and methodology present inherent limitations. The framework was primarily developed and evaluated within a selected group of mining companies in Zimbabwe. Its generalizability to all mining companies in Zimbabwe, or to other resource-

intensive sectors in similar economies, requires further validation. Differences in company size, operational focus and specific legacy systems could impact implementation success. Furthermore, using a DSR can be challenging and requires a thorough comprehension of the theoretical ideas and how they relate to research.

Building upon this foundational work, future research should focus on refining specific module functionalities based on real-world deployment by investigating the readiness, capabilities, and required capacity building for ERP vendors and local Zimbabwean IT service providers to implement, customise, and support the framework effectively. Also, large-scale longitudinal pilots of the framework should be implemented and rigorously evaluated across a diverse range of mining companies of different sizes and commodities in Zimbabwe over an extended period to quantify efficiency gains, sustainability improvements and user adoption metrics. In addition, the framework should be tested for its applicability and adaptability within the mining sectors of other cross-border nations facing similar challenges but potentially different regulatory landscapes, to assess its regional scalability and identify any necessary modifications.

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