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Leveraging Machine Learning and Artificial Intelligence for Innovation and Sustainability in Small and Medium Sized Enterprises (SMEs): A Case Study of Kalumbila, Zambia

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***Abstract*— Despite the rapid advancement and widespread adoption of Artificial Intelligence (AI) technologies across various sectors, the implementation of AI and Machine Learning (ML) in Small and Medium-sized Enterprises (SMEs) remains relatively underexplored. The incorporation of Artificial Intelligence and Machine Learning into Small and Medium sized Enterprises (SMEs) can transform conventional business procedures and provide substantial prospects for expansion and competitiveness. By utilizing AI and ML tools such as Predictive and Prescriptive Analytics, Deep Learning and Natural Language Processing, SMEs can streamline operations, increase productivity and make data-driven decisions. This study examines the various uses of AI and Machine Learning in SMEs, emphasizing how these technologies can enhance decision-making, optimize operational efficiency, and provide tailored consumer experience. The study focuses on SMEs within Kalumbila town, in North-Western Province of Zambia. Additionally, the paper highlights the challenges SMEs face in implementing these technologies, such as resource limitations, costs, and the requirement for specialized skills. Ultimately, the study shows that with right strategies and approaches, Machine Learning and Artificial Intelligence can be powerful enablers for innovation and sustainable growth for SMEs.**

Keywords: artificial intelligence, machine learning, SMEs, innovation, sustainability.

I. INTRODUCTION

The integration of Artificial Intelligence technologies into the industrial operations has fundamentally transformed many large organizations, ushering in a new era of innovation. These technologies have revolutionized industries by offering advanced analytical capabilities and automation. While large enterprises have been quick to adopt these technologies, Small and Medium-sized Enterprises (SMEs), have lagged in their adoption.

A. Kalumbila Town

Kalumbila Town, situated in Zambia's North-Western Province, is a rapidly developing area primarily driven by large-scale mining activities. While the economy is dominated by major enterprises such as First Quantum Minerals and Barrick Gold Corporation, Small and Medium-sized Enterprises (SMEs) play a vital role in supporting the broader economic ecosystem. Many of these SMEs are contracted to provide goods and services that support mining operations, including transportation, logistics, cleaning, and catering services. However, like many SMEs worldwide, those in Kalumbila have been slow to adopt advanced technologies such as Artificial Intelligence (AI) and Machine Learning (ML), which hold the potential to transform their operations and significantly enhance their contributions to local economic growth.

B. Importance of SMEs to local economic growth

Small and medium-sized enterprises (SMEs) are essential drivers of economic growth in most countries [26]. In developing nations, small and medium-sized enterprises (SMEs) account for more than 70% of employment and contribute roughly 35% to the GDP [27]. Table I below illustrates the contribution of SMEs to GDP and employment in various African countries [34].

TABLE I: Contribution of SMEs to GDP and employment in various African countries

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Countries	Contributions to GDP (%)	Contributions to employment (%)	References
Ethiopia	3.4%	90%	Central Statistic Agency (CSA), 2003; Gebrehiwot, 2006
Ghana	70%	49%	Ghana Bank Doing Business Report, 2013; World Bank, 2006; Abor & Quartery, 2010;
Kenya	40-50%	80%	Mwarari & Ngugi, 2013;
Nigeria	50%	70%	Ariyo, 2011; Kolasiński, 2012;
Rwanda	20.5%	60%	Mukamuganga, 2011
South Africa	50-60%	60%	DTI, 2012; Willemse, 2010;
Tanzania	60%	20%	Echengreen & Tong, 2005; Ngasongwa, 2002
Uganda	18%	90%	Uganda Ministry of Trade, Industry and Cooperatives (MTIC), 2015
Zambia	8%	30%	Mbuta, 2007
Zimbabwe	40%	15%	Katua, 2014; Zwinoira, 2015

In Kalumbila town, SMEs provide a significant portion of the local employment, engaging in sectors such as construction, retail, Transportation and logistics, and services. These businesses account for a large portion of the workforce, which are essential for sustaining not only the town's, but also the country's economy. Beyond job creation, the SMEs are key contributors to innovation, often pioneering new products, services, and processes that can reshape large industries. For example, the SMEs in Kalumbila are particularly important as they supply goods and services to the mining industry. Their flexibility and adaptability enable them to respond quickly to market changes, making them crucial to maintaining economic dynamism and fostering competitive markets. This combination of employment generation and innovation positions SMEs as a cornerstone of sustainable economic development. However, despite their critical role, these SMEs face challenges in adopting digital innovations. Their integration with global markets and cutting-edge technologies, such as AI and ML, remains limited, hindering their full potential to innovate, grow, and compete both locally and regionally.

C. Importance of Machine Learning and Artificial Intelligence to SMEs

Artificial Intelligence and Machine Learning can streamline various aspects of SME operations, enhancing efficiency and productivity [28]. For example, predictive analytics, powered by AI, can improve supply chain management by forecasting demand and reducing operational inefficiencies [5]. Furthermore, ML algorithms can enhance decision-making processes by analysing large datasets, which are often inaccessible or too complex for traditional methods [11]. The integration of these technologies can lead to improved customer engagement, better resource allocation, and strategic planning, ultimately fostering competitiveness and scalability for SMEs [12]. As SMEs represent a substantial share of employment and innovation, their growth and optimization through Artificial Intelligence and Machine Learning could have a wide-reaching impact on national and global economies.

C. Problem statement

SMEs face challenges such as resource constraints, high implementation costs, and the need for specialized skills, which hinder their ability to harness the potential of AI and ML [14]. Understanding how AI and ML can be effectively utilized in SMEs and identifying strategies to overcome these barriers is essential for fostering innovation and sustainable growth in this sector.

D. Objectives

Based on the problem identified above, our study has set out to achieve the following objectives;

1. Investigate how AI and ML can be leveraged to drive innovation and sustainable growth in SMEs.
2. Identify the AI and ML tools that can optimize business processes in SMEs.
3. Examine the challenges SMEs face in adopting AI and ML technologies.
4. Propose strategies for overcoming the barriers to AI and ML adoption in SMEs.
5. Assess how AI and ML can enhance operational efficiency and innovation capacity in SMEs.

E. Research questions

How can AI and Machine Learning drive innovation and sustainable growth in SMEs?

1. What specific AI and ML tools are most beneficial for improving operations in SMEs?
2. What are the primary challenges faced by SMEs in implementing AI and ML technologies?
3. What strategies can SMEs adopt to overcome the resource, cost, and skill-related barriers to AI and ML implementation?
4. How can AI and ML contribute to improving the operational efficiency and innovation capacity of SMEs?

II. LITERATURE REVIEW

A. AI and ML application in SMEs

AI and ML have been successfully implemented in various sectors, including healthcare, finance, and manufacturing, but their adoption in SMEs is still limited [15]. AI adoption in the healthcare sector has been applied to areas such as patient management systems, medicine supply, and other pharmaceutical needs [20]. Several studies highlight the potential applications of these technologies in SMEs, particularly in areas like predictive analytics [16], customer service [17], and operations management [17]. Predictive

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analytics, driven by AI and ML algorithms, can help SMEs forecast future demand and optimize their supply chains [5]. In marketing, AI tools enable the functional marketing areas to identify the customers and their buying behaviours [19] This aligns with [6], who argue that predictive models enable SMEs to make better decisions by analysing large datasets that would otherwise be inaccessible or difficult to interpret.

NLP powered chatbots can provide cost-effective customer service solutions for SMEs, automating routine queries and allowing human agents to focus on more complex tasks [13].

B. Challenges

Despite the potential benefits, numerous studies highlight significant barriers that SMEs face when attempting to adopt AI and ML technologies. A key obstacle is the insufficient allocation of resources to AI within operational units [18]. Resource limitations are particularly prevalent in African countries, where SMEs often lack financial capital. For example, [34] explains that access to funding is a major challenge in countries like Tanzania and Rwanda, with many SMEs struggling to secure financing from traditional sources such as banks.

In addition to financial constraints, skill shortages remain a critical challenge for SMEs. As noted by [9], AI and ML require specialized knowledge in data science and machine learning engineering, which many SMEs struggle to access due to competition for talent with larger companies. This lack of in-house expertise makes it difficult for SMEs to deploy and maintain sophisticated AI tools [21]. According to [7], human expertise is critical for implementing and maintaining AI systems. Additionally, [31] notes that limited access to technology and technical expertise poses a significant barrier to AI adoption in SMEs across sub-Saharan Africa, with cultural and language barriers further impeding the full utilization of AI in this region [32]. Moreover, lack of awareness and understanding of AI among SMEs in sub-Saharan Africa can impede its adoption [33]. This is often due to limited information and education regarding the potential benefits of AI and its applications for SMEs [32]. [8] Also point out that the high cost of AI infrastructure, such as cloud computing services and data storage, can deter SMEs from pursuing AI initiatives. Many SMEs struggle to integrate AI technologies with their current IT systems, which demands extra time, effort, and resources [23]. Furthermore, [9] argue that organizational culture is a key factor in successful AI adoption. They suggest that SMEs often face resistance to change, especially when employees are unfamiliar with new technologies [24]. User and external stakeholder acceptance of AI has been recognized as a major challenge to its adoption [25]. This resistance can hinder the integration of AI and ML systems into existing business processes, further slowing down innovation and digital transformation [24].

C. Strategies

One of the most common strategies is the use of cloud-based solutions. Cloud computing platforms, as discussed by [1], offer AI-as-a-Service (AIaaS) models that reduce the need for substantial upfront investments in infrastructure. These platforms provide scalable AI solutions that SMEs can use to pilot small projects before expanding their AI initiatives.

Collaborative efforts between SMEs and other organizations, such as universities or technology companies, also emerge as a viable strategy for overcoming resource and skill limitations. SMEs partner with external experts to access AI tools and expertise, allowing them to implement AI at a lower cost and with fewer risks [2]. Similarly, [3] highlight the value of government incentives and support programs that can provide SMEs with the financial backing and training opportunities needed to adopt AI.

III. METHODOLOGY

Given the complexity and underexplored nature of AI adoption in SMEs, a qualitative research approach was utilized to gain deeper insights into the opportunities and challenges that SMEs face.

A. Research Design

A qualitative research design was selected to capture data on the adoption of AI and ML technologies in Small and Medium-sized Enterprises. This approach was ideal for exploring new and complex phenomena where quantitative data may not fully reveal the underlying factors affecting the adoption of these technologies. The study utilized semi-structured interview to understand the experiences, applications, challenges and future outlook of integrating machine learning and artificial intelligence tools in Small and Medium-sized Enterprises. A purposive sampling method was utilized to select participants the SMEs [4]. This non-probability sampling technique is chosen to ensure that the participants can provide rich, detailed insights into the research topic. The study-targeted participants including, Managers, Employees, and Consultants from industries, such as, Healthcare, Transportation and logistics and other service contracted by the mines.

B. Data collection

Semi-structured interviews was utilized as the main method of data collection. Interviews were conducted with 10 participants to gather in-depth information on their experiences, awareness and perception of AI and machine learning technologies. Each interview approximately took 10 to 20

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minutes, and were recorded with participants' consent. The interview guide covered the following areas:

Understanding of AI and ML technologies: Participants were asked about their familiarity with AI and ML, and how these technologies were perceived within their organizations.

Applications of AI/ML in business operations: Questions explored the specific AI/ML tools in use, such as predictive analytics, NLP, or automation, and the perceived benefits of these tools.

Challenges in AI/ML implementation: Participants were asked to reflect on obstacles hindering the use of AI and machine learning tools in their organizations.

Future outlook: The interviews explored the participants' long-term expectations and strategies for AI integration.

C. Data Analysis

This study employed narrative analysis as the primary method for analysing interview data. Narrative analysis allows for a detailed examination of participants' responses to interpret and derive meaning from their experiences and insights [22]. Each interview transcript was used to construct a comprehensive case study narrative, capturing how SMEs perceive, implement, and interact with artificial intelligence and Machine Learning. These narratives were synthesized to identify common trends, patterns, and themes related to AI-driven business transformations, decision-making processes, and operational efficiencies.

IV. RESULTS AND FINDINGS

In examining feedback provided by respondents concerning the adoption of artificial intelligence technologies in SMEs, numerous key themes and valuable insights came to light. These insights provided a detailed understanding of the respondents level of artificial intelligence knowledge, perception of AI and willingness to adopt AI technologies in their organizations. Understanding the respondents' perception to adopt AI technologies is important as it helps examine factors that influence individuals' acceptance and use the technology [29]. This chapter highlights the characteristics of the respondents and presents the findings that were generated from the interviews based on the objects of the study and the following results were established.

D. Data presentation

1) *Education*

The education level data shows that the majority of participants, 60%, hold a **Bachelor's degree**, indicating that undergraduate education is the most common among the group**. 20%** have a **Diploma**, while **10%** have completed **High School**. Only **1%** hold a **Master's degree**, and there are no participants with a **PhD**. This suggests that while the sample is well educated, advanced postgraduate qualifications (Master's and PhD) are rare, with the Bachelor's degree being the dominant educational qualification in the group.

TABLE II: Educational Levels

Level of Education	**Frequency**	**Percentage**
High School	1	10%
Diploma	2	20%
Bachelor's degree	6	60%
Master's degree	1	1%
PhD	0	0%
Total	10	100%

2) *Occupation*

The findings presented in Table III describe the occupational distribution of respondents, with the largest proportion being mangers. This suggests that a significant portion of the respondents is involved in strategic decision-making. 30% of the respondents were employee, indicating that a smaller, yet substantial portion of the group is composed of individuals actively working in operational roles within the businesses. 20% of the respondents were IT consultants, reflecting a smaller but notable presence of external advisors or experts providing specialized knowledge.

TABLE III: Occupational distribution of respondents

Role	**Frequency**	**Percentage**
Manager	5	50%
Fulltime employee	3	30%
IT Consultant	2	20%
Total	10	100%

3) AI Knowledge

Table IV reveals that 50% of respondents have a basic understanding of artificial intelligence, indicating limited knowledge among many. Meanwhile, 30% rate their knowledge as intermediate, and 20% see themselves as advanced. Notably, no respondents classify themselves as experts, pointing to a gap

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in deep AI expertise. Overall, while most participants are somewhat familiar with AI, advanced and expert-level understanding is rare.

TABLE IV: Basic understanding of artificial intelligence

AI knowledge	**Frequency**	**Percentage**
Basic	5	50%
Intermediate	3	30%
Advanced	2	20%
Expert	0	0%
Total	10	100%

E. Summary of the findings

By examining the questionnaire data, this chapter endeavours to provide a comprehensive understanding of the participants' awareness and understanding of AI technologies, AI utilization in SMEs, challenges, and Future outlook.

1. Awareness and understanding of AI technologies

Respondents characterized their organizations' understanding of AI as limited as few employees in their various organizations are familiar with how AI can be applied to the operations. This suggests that while there is some awareness of AI technologies, a more profound knowledge and expertise may be lacking. Despite the limited understanding, respondents expressed optimism about the potential benefits of AI for their organizations. Key areas identified include; supporting decision-making processes through the utilization of data analytics tools, optimizing marketing strategies, automating repetitive tasks, and improving operational efficiencies. Respondents emphasized that AI technologies are crucial for the long-term success of their SMEs. They recognized that embracing AI is not just a trend but also a necessary step for staying competitive in an increasingly digital landscape.

2. Application

While respondents noted that their organizations are currently not utilizing artificial intelligence tools, they identified several areas that could improve with AI adoption. These areas include;

Transportation and logistics: Participants in the transportation and logistics sector highlighted several key applications of AI technologies. One participant mentioned, *"AI can be extremely useful for predictive maintenance. By using AI, we can anticipate vehicle failures before they happen, minimizing downtime and reducing repair costs."* Another respondent emphasized the benefits of AI in weather forecasting, stating, *"AI can help us predict weather conditions more accurately, which is crucial for planning routes and avoiding delays."* Furthermore, respondents discussed AI's role in fuel optimization, explaining, *"AI tools can analyse fuel consumption patterns and suggest more efficient driving practices or routes, saving us a lot on operational costs."*

Security services: Respondents highlighted how AI can enhance video surveillance by monitoring footage in real-time. One participant noted, *"AI in video surveillance would allow us to detect unusual activities instantly, improving our ability to manage risks and respond quickly to potential threats."* "AI's capability to analyse live video feeds helps in identifying suspicious behaviour or objects that might be missed by human operators." Beyond video surveillance, participants emphasized the usefulness of AI in object detection, explaining, *"AI-powered object detection systems can recognize specific items, helping us track assets and reduce theft incidents."*

Healthcare: In this sector, respondents acknowledged that AI could offer suggestions for diagnoses and treatment plans based on patient history and symptoms, thereby supporting medical professionals in making informed decisions and reducing the time required for patient examinations. Additionally, participants pointed to AI's application in medical imaging, noting, *"Automated image analysis powered by AI can quickly and accurately evaluate X-rays, MRIs, and CT scans, improving both speed and precision in diagnostics.*"

3. Challenges to AI adoption

Respondents expressed interest in adopting artificial intelligence technologies; however, they highlighted several challenges that hinder this progress. These challenges include; Lack of skilled personnel: One participant mentioned, *"We don't have enough skilled personnel who understand how to implement and manage AI systems, and this is a big barrier for us."* Lack of user education on artificial intelligence technologies: Another respondent added, *"There's a lack of user education on AI technologies, which makes it difficult for our staff to fully utilize these tools"* Limited knowledge about

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AI was also a concern, as m*ost people in SMEs are still not fully aware of how AI can benefit their business processes.*

Additional challenges cited included insufficient IT infrastructure, organizational resistance to change, and concerns over data privacy and security. As one respondent noted, *"there is still a lot of hesitation about data privacy and security when it comes to AI, which makes it harder for us to move forward."*

4. Future outlook

Respondents acknowledged that AI and machine learning (ML) technologies would significantly impact their businesses in the future. They identified several AI technologies that could benefit their SMEs, including deep learning, automation tools, robotics, facial detection and recognition tools, recommendation algorithms, digital assistants, and predictive analytics tools. For future AI and ML integration, respondents emphasized the importance of hiring or training staff with expertise in these areas, increasing budget allocations for AI and ML projects, collaborating with external AI technology providers, and exploring new applications across their businesses

V. DISCUSION

The findings from this study provide valuable insights into the current state of awareness, applications, and challenges surrounding artificial intelligence technologies in small and medium-sized enterprises (SMEs). The research reveals that while SMEs have limited understanding of AI technologies, they recognize AI's potential to improve decision-making, automate tasks, and enhance operational efficiency.

Although AI is not yet widely adopted by SMEs, this study highlights several areas where AI tools could offer significant benefits. In transportation and logistics, for instance, tools such as **IoT sensors** combined with **machine learning algorithms** like **anomaly detection models** or **regression analysis** can analyse vehicle data (e.g., engine temperature, vibration levels) to predict when maintenance is needed. Machine learning algorithms such as reinforcement learning can be utilized in vehicle optimization. Additionally, deep learning plays a role in video surveillance systems. For example, IBM's Watson Visual Recognition uses AI and deep learning to analyse images and video streams in real-time, detecting specific objects, unusual behaviours, or activities, thereby enhancing security monitoring. In healthcare, **machine-learning techniques,** such as artificial neural networks (ANN) can be utilized to improve delivery of care at reduced cost [30] and **natural language processing (NLP)** algorithms can be used to interpret medical data and provide insights to support medical professionals in decision-making.

Key challenges to adoption include a lack of skilled personnel, financial constraints, concerns over data privacy, and lack of IT infrastructure to support AI technologies. Addressing these issues will require a strategic focus on workforce development, infrastructure investment, and cultural shifts within organizations.

Looking ahead, SMEs anticipate significant impacts from AI and plan to invest in training, budget allocations, and partnerships to integrate AI technologies into their operations.

VI. IMPLICATIONS OF THE FINDINGS

A. Ethical considerations

In this study, ethical considerations surrounding the confidentiality and privacy of participants' information loom large and require careful attention. Safeguarding the privacy and confidentiality of participant data is not just a legal requirement but also a moral imperative that underpins the integrity and trustworthiness of the research process.

B. Limitations

It is important to acknowledge challenges and highlight various challenges that were encountered during this study, including power outages that led to disrupted research activities as the research depended on electronic devices and internet. Additionally, **time constraints** emerged as a critical issue, limiting the scope of the study and influencing the decision to adopt a **qualitative approach**. This approach was chosen to ensure depth and richness of data within the available timeframe.

VII. CONCLUSION

In conclusion, the findings emphasize a strong consensus among respondents that the adoption of machine learning and artificial intelligence has the potential to drive innovation and ensure the long-term sustainability of SMEs. This shared belief underscores the recognition that these advanced technologies are not just tools for improving efficiency but are also essential for maintaining competitiveness in an increasingly digital business landscape. The insights gained from this study underscore the importance of not only recognizing the value of AI but also actively pursuing the necessary steps to integrate these technologies into organizational practices for sustained growth and innovation. For future improvements, we recommend that the scope of the study be expanded to cover a larger geographical area, such as the entire North-Western Province. This expansion would allow for the inclusion of a more diverse range of Small and Medium Enterprises (SMEs),

capturing insights from businesses operating under different regional conditions, market dynamics, and economic environments. Additionally, we recommend that the study adopt a quantitative research methodology to allow for more objective analysis and statistical generalization.

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