Review Article

Mechanization in Zimbabwe's Smallholder Agriculture: Challenges, Opportunities, and Policy Pathways Since Land Reform

B. Chisadza[1], A. Mugoti[2*], S. Chinomona[1], D. Nyathi[3]

1- Department of Crop and Soil Science, Faculty of Agricultural Sciences, Lupane State University, Lupane, Zimbabwe
2- Department of Animal Science and Rangeland Management, Faculty of Agricultural Sciences, Lupane State University, Lupane, Zimbabwe
3- School of Public Management, Governance and Public Policy, University of Johannesburg, Gauteng, South Africa
(*- Corresponding Author Email: amugoti@lsu.ac.zw)
https://doi.org/10.22067/jam.2025.92819.1362

Abstract

Agricultural mechanization is a vital driver of productivity, food security, and sustainable farming in Zimbabwe and worldwide. Its transformative potential is increasingly recognized as essential for meeting food demand and fostering resilient rural economies. Yet, smallholder farmers face persistent barriers that limit access to modern technologies. Since the land reform era, systemic inefficiencies, inequalities, and weak institutional support have exacerbated these challenges. This study employed a narrative literature review, complemented by scoping techniques, to synthesize data from peer-reviewed publications, policy reports, and institutional documents (2000-2024). Thematic analysis revealed that only 12% of Zimbabwean smallholders use tractors, compared to 80% of large-scale farmers. Mechanization can double yields, as seen in Zimbabwe (100% increase) and up to 150% in comparable countries. However, regional disparities remain stark, ranging from 5–15% in arid provinces to over 50% in more productive areas. Opportunities lie in localized manufacturing hubs, climate-resilient technologies, and new financing models. Drawing on lessons from other African nations, this study highlights strategies such as improving policy coherence, expanding financing, and fostering public-private partnerships.

Keywords: Agricultural productivity, Climate-resilient technologies, Conservation agriculture, Food security, Small-scale farmers

Introduction

Agriculture remains the backbone of Zimbabwe's economy, providing most employment, ensuring food security, and contributing significantly to exports. However, the sector has undergone major transformations, shaped by historical, political, and socio-economic factors. A pivotal moment in this transformation was the Fast Track Land Reform Program (FTLRP) of 2000, which aimed to redistribute land from white commercial farmers to black indigenous farmers. While the program broadened land access, it also disrupted established agricultural production systems, particularly in mechanization and productivity (Makonese, 2017).

Prior to the FTLRP, Zimbabwe's commercial agricultural sector was highly mechanized, benefiting from well-developed infrastructure, access to credit, skilled labor, and a stable input supply chain (Chambati, 2013; Scoones *et al*., 2010). Large-scale commercial farms, predominantly white-owned, operated with a range of advanced mechanization technologies, including, but not limited to, tractors, combine harvesters, and sophisticated irrigation systems, enabling high productivity and substantial export earnings. However, the restructuring of land ownership under the FTLRP led to the emergence of predominantly smallholder farming systems, often characterized by limited access to essential resources such as capital, infrastructure, and modern mechanized technologies (Makonese, 2017). Consequently, mechanization levels dropped, negatively

affecting efficiency, productivity, and long-term sustainability of agriculture.

The shift towards smallholder farming has presented both opportunities and challenges. Smallholder agriculture refers to farming on small plots of land (usually less than 5 hectares), typically managed by families. It relies mainly on manual labor and simple tools, with production directed toward household consumption and local markets (FAO, 2019). The FTLRP has exposed critical systemic weaknesses, including inadequate infrastructure, limited government support, and unequal access to mechanization resources. Smallholder farmers often encounter challenges such as high machinery costs, political interference, and the preferential allocation of mechanization programs favoring affluent and influential individuals, further deepening social inequalities in the sector (Shonhe, 2019). Despite these constraints, the informal sector has played a critical role in bridging the mechanization gaps, with local entrepreneurs innovating low-cost, small-scale mechanization solutions tailored to smallholder needs (Mujeyi, Mutambara, Siziba, Sadomba, & Manyati, 2015).

Mechanization is a fundamental pillar of agricultural transformation, encompassing tools, implements, and machinery that enhance productivity, reduce labor intensity, and strengthen resilience against climate variability (FAO & AUC, 2019). In the face of labor shortages and increasing climatic uncertainties, mechanization has become more critical than ever in ensuring sustainable agricultural production. However, the adoption of mechanization in Zimbabwe remains uneven across different farming systems, necessitating a comprehensive assessment of its current state, challenges, and opportunities.

To achieve this, the study will first evaluate the current status of mechanization across smallholder and commercial farming sectors in Zimbabwe. It will analyze the types of machinery used, their distribution, and the level of adoption across different farming systems. Additionally, the research will assess the impact of government-led mechanization programs on enhancing productivity and improving accessibility for smallholder farmers.

Given the diverse nature of Zimbabwe's agricultural landscape, this study will also explore differentiation in mechanization strategies across various farmer categories. This study investigates factors such as farm size, location, market access, and available resources that influence the adoption and use of mechanization. Furthermore, challenges related to machinery importation, such as affordability, maintenance, and adaptability to local conditions, will be critically analyzed to understand the constraints faced by farmers and the agricultural sector at large.

Finally, based on the insights gathered, the study will propose actionable recommendations for a robust mechanization policy framework. These recommendations aim to enhance productivity, sustainability, and equitable access to mechanization technologies, ensuring that all farmers**,** especially smallholders**,** can benefit from advancements in agricultural mechanization. By addressing these key areas, this research aims to contribute to policy development that fosters inclusive and sustainable mechanization in Zimbabwe's agricultural sector.

Review Methodology

This study employed a narrative literature review approach, complemented by scoping elements, to investigate the evolution, current status, and future trajectories of agricultural mechanization in Zimbabwe's smallholder sector as shown in Figure 1. A comprehensive synthesis of peer-reviewed articles, policy reports, and institutional publications from national and international sources published between 2000 and 2024 was conducted. Relevant literature was identified through keyword searches conducted in databases such as Google Scholar, Scopus, and AGRIS, using terms like "agricultural mechanization Zimbabwe" and "smallholder farming. The review also incorporated grey literature and

case studies from government and donor agencies, including the FAO and IFPRI. Thematic analysis of selected sources examined historical transitions, institutional mechanisms, policy frameworks, regional disparities, and challenges. This provided a nuanced understanding of Zimbabwe's mechanization landscape and highlighted policy gaps, contextual barriers, and strategic opportunities for scaling inclusive mechanization.

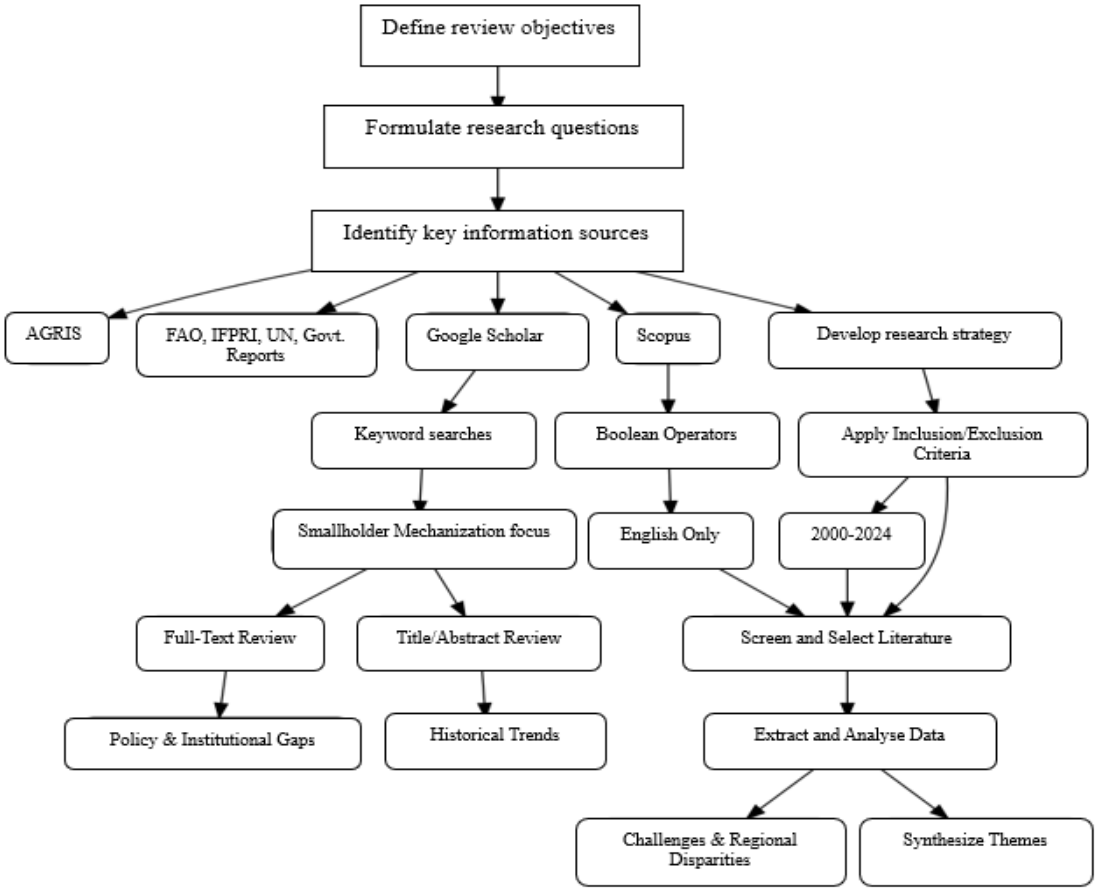

Fig. 1. Review methodology

Historical Context and Mechanization Transition

The history of agricultural mechanization in Zimbabwe is closely tied to both the country's colonial period and post-independence era. Before the 2000 Fast Track Land Reform Program (FTLRP), the commercial farming sector, largely dominated by white farmers, benefited from significant investments in mechanized farming systems (Moyo, 2014; Mukembo & Edwards, 2015). By the late 1990s, Zimbabwe's commercial agriculture was among the most mechanized in sub-Saharan Africa, with widespread use of tractors, combine harvesters, and irrigation systems (Moyo, 2014). These advancements relied on government-backed credit facilities, technical training, and efficient supply chains for inputs and spare parts, which facilitated widespread mechanization (Scoones *et al.*, 2010).

Mechanized farming practices, including the use of combine harvesters, planters, and sprayers, significantly increased productivity and efficiency during this period (Arslan *et al.*, 2020). However, the FTLRP altered this landscape by dividing large-scale farms into smaller plots, often lacking the necessary infrastructure or resources for mechanized operations. Many newly resettled farmers lacked the capital and technical skills

necessary to maintain or acquire machinery, which triggered a sharp decline in mechanization rates (Gopalakrishnan & Banerji, 2013). As a result, there was a significant shift towards manual labor and animal-drawn implements, which were more accessible but far less efficient (Chambati, 2013).

Mechanization challenges post-FTLRP were worsened by weak government policies and political interference, disrupting the establishment of effective support systems for smallholder farmers (Kang'ethe & Serima, 2014). Limited access to mechanization resources disproportionately affected smallholders, who constitute over 70% of Zimbabwe's population relying on agriculture for their livelihoods, typically cultivating average farm sizes of about 3.4 hectares, which is below the 5-ha threshold for optimal mechanization (Chimonyo, Baudron, & Matangi, 2023). Wealthier and better-connected farmers continued to benefit from private investments or partnerships with international donors (Shonhe, 2019). In contrast, the majority of smallholder farmers struggled to overcome systemic barriers, reinforcing disparities within the agricultural sector (Chambati, 2013).

This transition also had significant implications for the agricultural labor market. Job losses for skilled workers previously employed on large-scale farms led to a decline in technical expertise (Shonhe, Scoones, & Murimbarimba, 2020). Concurrently, declined mechanization capacity led to labor-intensive farming practices, with many farmers depending on family labor to sustain operations. These labor dynamics, coupled with low mechanization rates, have contributed to persistent productivity challenges within the smallholder sector (Shonhe *et al*., 2020).

Despite these setbacks, efforts have been made to explore opportunities for addressing the mechanization gap. Informal sector entrepreneurs have stepped in, developing cost-effective and context-specific technologies for smallholder farmers (Mujeyi *et al*., 2015). Additionally, innovative approaches, such as two-wheel tractor-based service models, have shown promise in improving access to mechanization for resource-constrained farmers (Ngoma, Simutowe, & Thierfelder, 2023).

Current State of Mechanization

Zimbabwe's agricultural mechanization landscape is characterized by stark disparities, particularly between smallholder and large-scale farmers. Small-scale farmers, who form the majority of Zimbabwe's agricultural population, rely predominantly on manual labor and animal-drawn equipment, with only 12% using tractors. In contrast, 80% of large-scale farmers have access to advanced mechanized systems, highlighting major inequalities in access to technology and resources (Simutowe *et al*., 2023; Zimbabwe National Statistics Agency, 2019). This disparity aligns with broader trends observed in many developing countries, where wealth and political connections often influence access to mechanization (Shonhe, 2019).

At the regional level, Zimbabwe lags behind in mechanization rates, further emphasizing its structural challenges. Figure 2 highlights the steady growth in tractor adoption. However, Zimbabwe remains behind regional leaders like South Africa and Kenya, underscoring the need for targeted investments to bridge the mechanization gap (FAO, 2019). This mechanization gap has direct implications for food security and economic development, as mechanization is a critical driver of agricultural productivity. It enhances yields, reduces the burden of agricultural labor, and ensures the timely execution of farming operations, all of which are essential for improving livelihoods and strengthening resilience against climate change (FAO, 2019). However, systemic barriers, such as the high cost of machinery, limited access to financing, inadequate infrastructure, and weak supply chains for spare parts and maintenance, have hindered many smallholder farmers from benefiting from these advantages (Kang'ethe & Serima, 2014).

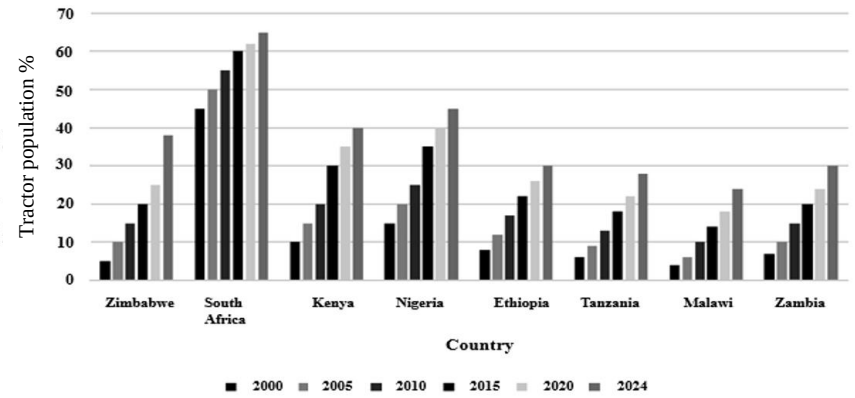

Fig. 2. Trends in tractor adoption over time (FAO, 2008; IFPRI, 2020; Ngoma *et al*., 2023; Madzivanzira *et al.*, 2024; Ngwarati, 2024; UN, 2019)

Despite these challenges, there are examples of progress in addressing Zimbabwe's mechanization gap. The Mechanization and Irrigation Development Fund has provided subsidized tractors to some farmers, while informal entrepreneurs have contributed by manufacturing affordable and locally tailored equipment for smallholders (Mujeyi *et al*., 2015). Conservation agriculture initiatives also promote practices that reduce reliance on heavy machinery, such as no-till farming systems, which align with sustainable agricultural mechanization principles (Sims & Kienzle 2017). Furthermore, service provider models using two-wheel tractors have shown potential to increase mechanization access for resource-constrained farmers by offering affordable mechanized services on a pay-per-use basis (Ngoma *et al*., 2023).

These initiatives, though promising, remain limited in scope and coverage. Addressing the mechanization disparities in Zimbabwe will require a more robust, inclusive, and coordinated approach, including increased public and private sector investments, supportive policies, and expanded training programs for smallholder farmers to enhance their technical skills and ability to adopt mechanization. Table 1 illustrates how mechanization has doubled productivity in Zimbabwe (100% increase) and significantly boosted yields in other nations, emphasizing the critical role of mechanization in achieving food security and economic development.

Table 1- Productivity changes linked to mechanization

Country	Pre-mechanization yield (tonnes ha^{-1})	Post-mechanization yield (tonnes ha^{-1})	Percentage increase	Reference
Zimbabwe	1.5	3.0	100	FAO, 2008
South Africa	3.0	6.5	117	UN, 2019
Kenya	1.8	3.5	94	IFPRI, 2020
Nigeria	2.0	4.2	110	FAO, 2008
Ethiopia	1.2	2.8	133	UN, 2019
Tanzania	1.0	2.5	150	IFPRI, 2020
Malawi	0.9	2.0	122	Ngoma *et al*., 2023
Zambia	1.4	3.2	129	FAO, 2008

Government-Led Mechanization Initiatives

The government of Zimbabwe has implemented several initiatives aimed at promoting mechanization in the agricultural sector. One of the most significant efforts was the Tractorization Scheme, which was launched in 2012 by the Ministry of Agriculture, Mechanization, and Irrigation

Development. This program provided subsidized tractors to farmers, with the goal of increasing mechanization rates and improve agricultural productivity (Houmy *et al*., 2013).

Similarly, the Mechanization and Irrigation Development Fund, created in 2015, provided subsidized loans to farmers and agricultural businesses to finance mechanization and irrigation projects (Government of Zimbabwe, 2015; Mhembwe, Chiunya, & Dube, 2019), as shown in Table 2. This fund seeks to enhance access to machinery and irrigation technologies to bolster productivity.

Table 2- Different financing models for mechanization

Financing model	Zimbabwe	South Africa	Kenya	Nigeria	Ethiopia	Tanzania	Malawi	Zambia	Reference
Government Subsidies	Yes	Yes	Yes	No	Yes	No	Yes	Yes	FAO, 2008
Bank Loans	Limited	Yes	Yes	Yes	Yes	Limited	Limited	Yes	IFPRI, 2020
Private Investment	No	Yes	Limited	Yes	No	No	No	Yes	UN, 2019
Donor Funding	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Ngoma *et al*., 2023
Cooperative Ownership Models	Yes	Limited	Yes	No	Yes	Yes	Yes	Yes	FAO, 2008

In addition to financing, the government has invested in mechanization centers across the country to support farmers in different agroecological regions. These centers provide training and technical support to farmers on the operation and maintenance of mechanized equipment (Madzivanzira *et al*., 2024). Equipped with modern machinery, they offer services such as tractor and equipment maintenance, repairs, and training on mechanized farming practices. Such initiatives aim to address gaps in technical expertise, which is a critical barrier to effective mechanization adoption. Table 3 highlights the uneven distribution of mechanization rates across Zimbabwe's provinces, with arid regions like Matabeleland South facing severe challenges due to low investment and poor infrastructure. This disparity underscores the urgency of developing tailored policies and investment strategies to bridge regional gaps.

Table 3- Mechanization rates by province and agroecological region in Zimbabwe

Province	Agroecological region	Mechanization rate (%)	Key challenges	Proposed solutions	Reference
Mashonaland West	Region IIa	50-60	High machinery costs, maintenance issues	Subsidized financing, improved repair services	FAO, 2008
Mashonaland Central	Region IIa & IIb	45-55	Limited skilled operators, access to spare parts	Training programs, local manufacturing support	IFPRI, 2020
Mashonaland East	Region IIa & IIb	40-50	High credit access barriers	Microfinance schemes, cooperative ownership	UN, 2019
Midlands	Region III	30-40	Smallholder farm sizes, limited technology access	Mechanization hubs, contract farming partnerships	Ngoma *et al*., 2023
Manicaland	Region I & II	35-45	Rugged terrain, affordability issues	Adapted machinery, rural credit facilities	FAO, 2008

Masvingo	Region IV & V	20-30	Dry conditions, low adoption of mechanization	Drought-resistant equipment, extension services	IFPRI, 2020
Matabeleland North	Region IV & V	10-20	Limited financial support, poor infrastructure	Infrastructure development, mechanization subsidies	UN, 2019
Matabeleland South	Region V	5-15	Low investment in mechanization, arid conditions	Public-private investment, lease-to-own models	Ngoma *et al*., 2023

The Zimbabwean government has also championed conservation agriculture as part of its mechanization strategy. Conservation agriculture focuses on minimizing soil disturbance, preserving organic matter, and promoting soil biodiversity. Supported by partnerships with international organizations and non-governmental organizations, programs in this domain provide training on practices like minimum tillage, the use of cover crops, and crop rotations (Nyamangara, Masvaya, Tirivavi, & Nyengerai, 2013; Thierfelder *et al*., 2018). These initiatives seek to align mechanization efforts with sustainable agricultural practices, which are essential for long-term productivity and environmental preservation.

Despite ongoing initiatives, significant challenges persist. Limited funding has restricted the scale and impact of government-led mechanization programs, with available resources often insufficient to meet the high demand for equipment and services (Madzivanzira *et al*., 2024). Infrastructural inadequacies, such as poor road networks and limited access to spare parts, further impede the effectiveness of these initiatives. A lack of technical expertise among both farmers and extension officers also undermines the adoption and maintenance of mechanized equipment (Shonhe, 2019).

Beyond these, several systemic barriers specifically hinder progress. Persistent funding gaps mean the majority of smallholder applications for equipment support go unmet. Less than 15% of rural service centers have access to essential spare parts, severely limiting equipment maintenance and use (Ngoma *et al*., 2023). Furthermore, the availability of trained technicians remains critically low; current extension-to-farmer ratios in Zimbabwe hover around 1:800, well above the recommended 1:500 standard for effective service delivery (Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement, 2019).

Addressing these issues requires multi-faceted solutions. The prohibitive initial capital outlay for equipment remains a major barrier for most smallholder farmers, compounded by high operating costs like fuel and repairs (Daum & Birner, 2020; Madzivanzira *et al*., 2024). Solutions here include promoting affordable mechanization models such as machinery hiring services (perhaps through farmer cooperatives or private entrepreneurs), credit schemes with favorable interest rates, government subsidies on essential equipment or fuel, and the dissemination of low-cost, locally adaptable machinery (IFPRI, 2020; Sims & Kienzle, 2017; African Development Bank [AfDB], 2023). To tackle repair and maintenance challenges, it is crucial to establish rural mechanization service centers equipped with spare parts and skilled mechanics (Gopalakrishnan & Banerji, 2013; Mukembo & Edwards, 2015). Introducing vocational training initiatives focused on agricultural machinery repair and maintenance, alongside promoting local spare parts manufacturing, can significantly diminish dependence on costly imports and reduce operational downtimes (Arslan *et al*., 2020; FAO & AUC, 2019).

Regarding appropriate technology, many imported machines are often designed for large-scale commercial farming and aren't well-suited for the diverse topography, soil

types, and small plot sizes of smallholder farms (Madzivanzira *et al*., 2024). Investing in research and development (R&D) for context-specific mechanization solutions (like power tillers, small tractors, or appropriate planting and harvesting tools) and encouraging farmer-led innovation and local adaptation of technologies is vital (Ngoma *et al*., 2023). To improve knowledge and skills, comprehensive training programs for farmers on equipment operation, maintenance, and precision agriculture techniques are essential (FAO, 2008; Kienzle & Sims, 2014). We also need to strengthen agricultural extension services through specialized training on mechanization and effective demonstration methods (Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement, 2019).

Policy and institutional gaps, including inconsistent policies, weak regulatory frameworks, and insufficient institutional support, also hinder the sector's growth (Baudron *et al*., 2019; Mkodzongi & Lawrence, 2019). Developing a clear and coherent national mechanization policy that addresses funding, training, infrastructure, and technology development; establishing dedicated institutions or departments to coordinate and promote agricultural mechanization effectively; and facilitating public-private partnerships to leverage resources and expertise are necessary steps (Government of Zimbabwe, 2015; Ngoma *et al*., 2023). Increasing awareness of environmental challenges linked to fossil fuel dependency, such as greenhouse gas emissions and soil compaction, highlights the need to champion energy-efficient machinery and alternative energy solutions, including solar irrigation pumps and electric agricultural vehicles. Furthermore, integrating conservation agriculture practices with mechanization is vital (Singh *et al*., 2020; Thierfelder *et al*., 2018).

Despite these constraints, scalable solutions are emerging. Malawi's tiered equipment leasing model, for example, has significantly increased smallholder access by 58% (AfDB, 2023). Similarly, Zambia’s mobile technician program has proven effective, reducing equipment downtime by 75% (Chimonyo *et al*., 2023). Both models present adaptable frameworks for Zimbabwe, particularly through targeted Public-Private Partnerships, offering valuable pathways for progress.

Critiques of these programs highlight their bias toward large-scale farmers, who typically have better access to credit, markets, and technical knowledge (Scoones *et al*., 2010). Smallholder farmers, who form the majority of Zimbabwe's agricultural population, often lack the resources or skills needed to participate in these programs and are thus excluded from the benefits of mechanization. Addressing this imbalance requires a more inclusive approach that prioritizes smallholder farmers through targeted subsidies, capacity building, and equitable resource distribution.

Challenges in Mechanization

Zimbabwe's agricultural potential is constrained by significant land use disparities. The country has approximately 4.13 million hectares of arable land, yet only about 25% is actively cultivated, mostly using manual and animal draught power (International Trade Administration, 2023). Irrigation coverage remains critically low, with just over 217,000 hectares under irrigation in 2024, representing roughly 5.3% of the arable land (The Herald, 2024). The remaining cultivated areas are predominantly rainfed and vulnerable to climate variability. These land use constraints, particularly the dominance of rainfed agriculture and limited mechanized cultivation, underscore the broader challenges facing agricultural mechanization in Zimbabwe.

Agricultural mechanization in Zimbabwe faces numerous challenges that significantly hinder its adoption and effectiveness, particularly among smallholder farmers. These challenges (Table 4 and Table 5) are multifaceted, encompassing economic, technical, infrastructural, and institutional barriers. Notably, these issues are interrelated, compounding the difficulties faced by farmers. The challenges presented in Table 4 are

closely interconnected. For instance, inadequate infrastructure not only increases operational costs but also exacerbates economic barriers by limiting farmers' ability to access financing and markets. For example, the high costs of machinery are exacerbated by limited financing options, while inadequate infrastructure increases operational costs and limits market access for mechanized services (Pingali, 2007).

Table 4- Key challenges facing agricultural mechanization in Zimbabwe

Category	Challenge
Economic	High costs of machinery, limited access to credit, high interest rates, and collateral requirements (Stamborowski, 2023).
Technical	Lack of technical expertise, inadequate training, and limited local manufacturing of machinery (Arslan *et al*., 2020).
Infrastructural	Poor road networks, insufficient storage facilities, and unreliable energy supply (Scoones *et al*., 2010).
Institutional	Inadequate policy frameworks, import duties on equipment, and bureaucratic hurdles in accessing support (Chigunhah, Svotwa, Mabvure, Munyoro, & Chikazhe, 2020; Madzivanzira *et al*., 2024).
Climate-related	Increased frequency of extreme weather events damaging machinery and reducing operational viability (Ndlovu, Prinsloo, & Le Roux, 2020).

Additionally, the lack of domestic manufacturing facilities drives up the prices of spare parts, rendering equipment maintenance both costly and time-intensive (Gopalakrishnan & Banerji, 2013). Institutional barriers, such as high import duties and cumbersome regulations, further hinder investment in mechanization.

Table 5- Mechanization rates, challenges, and solutions in Zimbabwe and selected African countries

Country	Mechanization rate (%)	Key challenges	Proposed solutions	Reference
Zimbabwe	~20-30	High cost of machinery, limited access to financing, inadequate maintenance services, lack of skilled operators	Subsidized loans, cooperative ownership models, local training programs	FAO, 2008
South Africa	~60-70	High initial investment, environmental concerns, rural infrastructure constraints	Government incentives, precision farming integration, investment in infrastructure	UN, 2019
Kenya	~30-40	Small farm sizes, lack of financial support, inadequate mechanization policies	Public-private partnerships, microfinance for farmers, mechanization hubs	IFPRI, 2020
Nigeria	~35-50	Limited spare parts availability, poor credit access, dependence on outdated machinery	Local manufacturing support, credit schemes, import duty reductions	FAO, 2008
Ethiopia	~25-35	Fragmented land ownership, limited technical expertise, affordability issues	Land consolidation efforts, vocational training, increased mechanization subsidies	UN, 2019
Tanzania	~20-30	Low adoption of technology, inadequate extension services, high machinery costs	Strengthening extension services, promoting affordable machinery, facilitating access to credit	IFPRI, 2020
Malawi	~15-25	High machinery costs, limited access to financing, lack of awareness about benefits of mechanization	Subsidized machinery programs, farmer education initiatives, development of hire services	Ngoma *et al*., 2023
Zambia	~25-35	Limited access to appropriate machinery, high operational costs, inadequate training for operators	Establishment of mechanization centers, training programs, promotion of locally manufactured equipment	FAO, 2008

The high cost of mechanized equipment remains a critical barrier. Tractor prices range from $10,000 to $50,000, which greatly exceeds the financial capacity of most small-scale farmers, who typically have limited resources (Stamborowski, 2023). Limited access to affordable financing options exacerbates this challenge, with high interest rates and stringent collateral requirements imposed by commercial banks rendering credit inaccessible for many farmers (Chigunhah *et al*., 2020).

The lack of technical expertise further undermines mechanization efforts. Many farmers lack training in the operation and maintenance of mechanized equipment, leading to frequent breakdowns and reduced productivity (Arslan *et al*., 2020). The absence of locally available technical support exacerbates these challenges, leaving farmers ill-equipped to address equipment issues promptly. Consequently, downtime becomes a common issue, significantly affecting farm operations.

Another pressing issue is the limited availability of spare parts and maintenance services. Most farmers rely on imported spare parts, which are both expensive and difficult to obtain (Gopalakrishnan & Banerji, 2013). The lack of local manufacturing and assembly facilities for mechanized equipment increases dependence on foreign companies for maintenance and repair services, further driving up costs and creating delays (Moyo, 2014).

Zimbabwe's weak rural infrastructure poses additional challenges. Poor road conditions in rural areas make it difficult to transport machinery and agricultural inputs to farms, while the lack of secure storage facilities exposes equipment to theft and environmental damage (Scoones *et al*., 2010). These infrastructural deficiencies add to the operational costs and inefficiencies associated with mechanized farming.

Government policies and regulations have also been identified as obstacles to mechanization. High import duties and taxes on mechanized equipment make it prohibitively expensive for farmers to procure essential tools. Furthermore, regulatory requirements, such as the need for permits and licenses, create bureaucratic hurdles that discourage mechanization adoption (Madzivanzira *et al*., 2024).

Climate change and variability have introduced new challenges to mechanization in Zimbabwe. Extreme weather events, such as droughts and floods, can damage equipment and disrupt agricultural operations (Ndlovu *et al*., 2020). Moreover, the lack of climate-resilient mechanized technologies limits farmers' ability to adapt to these changing conditions, further undermining their productivity and resilience.

Despite these challenges, there are promising developments that demonstrate potential pathways for overcoming these barriers. The rise of small-scale machinery rental services and collaborative farming models offers innovative solutions, enabling farmers to access equipment on a pay-per-use basis, thereby reducing the financial burden of ownership (Ngoma *et al*., 2023). Conservation agriculture practices, which emphasize minimal soil disturbance, have also emerged as a viable alternative, promoting sustainable farming while reducing reliance on heavy machinery (Thierfelder *et al*., 2018). Informal sector entrepreneurs have further contributed by developing cost-effective and context-specific tools tailored to smallholder needs (Mujeyi *et al*., 2015).

Addressing the mechanization challenges in Zimbabwe requires a holistic and inclusive approach that prioritizes smallholder farmers. This includes improving access to affordable financing, expanding technical training programs, investing in rural infrastructure, and enacting supportive policies to reduce costs and administrative burdens. Only through coordinated efforts can Zimbabwe's agricultural sector realize the transformative potential of mechanization.

Mechanization Policy

A robust and well-structured mechanization policy is essential for addressing challenges hindering adoption and ensuring sustainable agricultural development in Zimbabwe. Such a policy must be inclusive, comprehensive, practical and evidence-based, drawing lessons from both local experiences and successful international models (Sims & Kienzle, 2017).

To achieve sustainable development, an effective mechanization policy should encompass key components to address economic, technical, and environmental challenges. Targeted subsidies and credit facilities are crucial for making machinery affordable for smallholder farmers (Madzivanzira *et al.*, 2024; Masawe, 1994). Ethiopia's Agricultural Transformation Agency serves as a notable example, utilizing low-interest credit schemes and subsidized initiatives to markedly enhance mechanization rates (Houmy *et al*., 2013). In Zimbabwe, implementing similar financial instruments tailored to the needs of smallholder farmers would enable them to access essential equipment without straining their limited financial resources (Chigunhah *et al*., 2020).

Support for local manufacturing is another critical area. Developing local manufacturing and assembly plants can reduce dependency on expensive imports while ensuring spare parts and maintenance services remain easily accessible. Tax incentives, grants, and public-private partnerships could foster the growth of domestic industries capable of manufacturing affordable and tailored mechanization tools designed for smallholder farmers (Mujeyi *et al*., 2015). During Zimbabwe's economic challenges, the informal metal industry demonstrated significant potential by innovating mechanized tools to fill gaps left by formal suppliers (Mujeyi *et al*., 2015). Targeted support for this sector has the potential to significantly boost access to mechanization.

Capacity building must also be a priority. Many farmers and extension workers lack the training necessary to operate and maintain mechanized equipment effectively, which reduces productivity and increases equipment downtime (Arslan *et al*., 2020). Establishing demonstration centers and vocational training schools, coupled with the dissemination of user-friendly manuals, can help equip stakeholders with critical skills (Mukembo & Edwards, 2015). Partnering with agricultural research institutions to adapt mechanized technologies to Zimbabwe's diverse agroecological conditions would further enhance this effort.

Environmental sustainability should be at the forefront of mechanization policy. Conservation agriculture methods and renewable energy-driven machinery can reduce environmental impacts while increasing productivity (Thierfelder *et al*., 2018). Policies promoting practices like minimum tillage, crop rotation, and the adoption of renewable energy-powered tractors or irrigation systems can align mechanization with climate resilience and sustainability goals (Arslan *et al*., 2020; Sims & Kienzle, 2017).

Monitoring and evaluation frameworks are essential to track progress, ensure accountability, and facilitate continuous improvement. Indicators such as the number of farmers adopting mechanized equipment, the area under mechanized farming, and changes in productivity can provide actionable insights for policy refinement (Madzivanzira *et al*., 2024).

Zimbabwe's current mechanization efforts, such as the Tractorization Scheme and the Mechanization and Irrigation Development Fund, have shown some progress. However, these initiatives have been criticized for their limited scope and a disproportionate emphasis on large-scale farmers, neglecting the needs of smallholder farmers (Scoones *et al*., 2010). Existing policies are fragmented and incoherent, highlighting the need for a comprehensive and integrated approach.

An effective mechanization policy should outline clear goals, strategies, and stakeholder roles. It should be grounded in a thorough analysis of Zimbabwe's agricultural sector, considering crop and livestock types, farming systems, and resource availability, including land, labor, and capital (Mango, Siziba, &

Makate, 2017). Furthermore, it should align with broader national objectives, such as economic development, social equity, and environmental sustainability (Moyo, 2014).

Promoting local manufacturing and assembly would not only reduce costs but also enhance accessibility. Research and development initiatives should ensure that mechanized technologies are designed to suit Zimbabwe's diverse farming contexts (Kienzle & Sims, 2014). Integrating conservation agriculture methods and renewable energy solutions into mechanization strategies can enhance productivity while advancing environmental preservation (Madzivanzira *et al*., 2024). To achieve meaningful progress, Zimbabwe must prioritize an inclusive mechanization policy that places smallholder farmers at its core.

Opportunities and Solutions

Zimbabwe holds immense potential to enhance agricultural productivity through increased mechanization. However, unlocking this potential requires a multifaceted approach that leverages the country's unique strengths, aligns with its agroecological and socio-economic realities, and incorporates lessons from other African nations.

One significant opportunity lies in localized manufacturing and assembly. Establishing domestic factories for agricultural machinery could substantially reduce costs, improve access to spare parts, and stimulate local economic growth. The informal metal industry in Zimbabwe has already demonstrated its capacity to innovate and address mechanization needs during economic crises, providing a foundation for scaling up local manufacturing (Mujeyi *et al*., 2015). Similar initiatives in countries like Nigeria have shown that local assembly plants not only reduce costs for farmers but also create employment opportunities in the manufacturing sector (Olaoye, 2014).

Public-private partnerships (PPPs) present another critical avenue for advancing mechanization. By fostering collaboration between the government, private sector, and international donors, Zimbabwe can mobilize resources, expertise, and infrastructure to scale up mechanization initiatives effectively. Zambia's 'Mechanization for Rural Transformation' program is an example of how PPPs have facilitated access to affordable credit, training, and equipment, leading to improved productivity and the livelihoods of farmers (Üllenberg, Minah, Rauch, & Richter, 2017).

Climate-resilient technologies are also essential for adapting to the challenges posed by climate change. The adoption of weather-adaptive machinery and sustainable farming practices, such as minimum tillage and precision agriculture, can mitigate the impact of climate variability and enhance agricultural resilience (Arslan *et al*., 2020; Thierfelder *et al*., 2018). For example, integrating drought-resistant crop varieties with mechanized irrigation systems can significantly improve yields while reducing farmers' vulnerability to extreme weather events (Ndlovu *et al*., 2020).

Digital innovations offer significant potential for mechanization in Zimbabwe. Mobile-based platforms can streamline machinery sharing, market access, and technical support, improving efficiency and accessibility for smallholder farmers. Ghana provides a successful example, where apps have enabled farmers to connect with tractor owners, reducing transaction costs and expanding access to mechanization services (Ngissah, 2023).

A comprehensive national mechanization strategy is crucial for guiding and supporting these efforts. This policy should align with Zimbabwe's broader national development goals, address the specific needs of smallholder farmers, and attract funding from international and domestic sources (Mango *et al*., 2017). The strategy must emphasize inclusivity and sustainability, ensuring that mechanization efforts benefit all farmers, particularly those in marginalized rural areas (Scoones *et al*., 2010).

Cultural and ethical considerations in mechanization

Mechanization efforts in smallholder

farming must be sensitive to the cultural and social contexts in which they operate (FAO, 2014). This is crucial, as traditional farming practices are deeply rooted in local cultures and customs, and mechanization efforts must respect and build upon this existing knowledge and expertise (Kiptot & Franzel, 2014). A participatory approach, involving local communities in the design and implementation of mechanization initiatives, ensures solutions are tailored to local needs and contexts (Koech, 2022). Capacity building programs for local farmers focus on the operation, maintenance, and repair of machinery (IFAD, 2019). Furthermore, promoting the adoption of mechanized tools that complement rather than replace traditional farming methods is essential (Singh *et al*., 2020). Recognizing and valuing local knowledge and expertise, and incorporating it into mechanization initiatives, is also essential (Daum & Birner, 2020).

Furthermore, women play a vital role in smallholder farming systems, yet they often face significant barriers when it comes to accessing resources, training, and markets (FAO, 2018). Strategies to ensure equitable access to mechanization opportunities include providing gender-sensitive training programs that cater to the needs and preferences of women farmers (Muhwezi, 2003). Ensuring women have equal access to credit and finance mechanisms enables them to purchase and maintain machinery (Musabanganji, Antoine, & Lebailly, 2015). Developing and advancing mechanization solutions specifically tailored for women, considering their physical capabilities, mobility, and unique needs, is equally essential (Wanjiku, Manyengo, Oluoch-Kosura, & Karugia, 2007). Ultimately, ensuring women are involved in decision-making processes related to mechanization initiatives, from planning to implementation, is crucial (Koech, 2022).

Case Studies on Mechanization Strategies in Africa

Agricultural mechanization is widely recognized as a key driver for enhancing productivity, improving efficiency, and promoting food security in sub-Saharan Africa. The adoption of mechanized tools, such as tractors and harvesters, has the potential to revolutionize smallholder farming, which predominates in many countries across the continent. While Zimbabwe has embarked on various mechanization initiatives, it can benefit from lessons learned from other African nations that have implemented similar strategies to foster agricultural growth.

In Malawi, the Agricultural Development and Marketing Corporation (ADMARC) has established a successful tractor hiring scheme to provide smallholder farmers with affordable access to mechanized services (Chinsinga, 2018). This initiative targets rural farmers who otherwise cannot afford the high capital cost of purchasing a tractor. The scheme allows farmers to hire tractors for land preparation, planting, and harvesting at reasonable rates. ADMARC's tractor hiring service has helped smallholder farmers increase their acreage, leading to improved crop yields and higher productivity. Studies show that the availability of mechanized services has allowed farmers to expand their land under cultivation and use modern farming practices, resulting in increased income levels and food security (Chinsinga, 2018). However, challenges remain, such as maintenance and availability of equipment, as tractors can sometimes break down. Additionally, some farmers report that timely access to machinery during peak planting seasons can limit the potential benefits of the program (Chinsinga, 2018). Zimbabwe could adopt and scale ADMARC's tractor hiring model by ensuring an adequate number of service providers, improving equipment maintenance practices, and investing in more accessible machinery rental systems.

In Tanzania, the Agricultural Development Bank (TADB) provides smallholder farmers with credit facilities for the purchase of machinery, including tractors and plows (Mpogole, Dimoso, & Mayaya, 2020). This initiative has facilitated the mechanization of farming for smallholder farmers who lack the capital to purchase machinery outright. The credit facility scheme has been instrumental in

increasing mechanization adoption in Tanzania, enabling farmers to access equipment and modernize their farming methods. The program has contributed to higher yields in key staple crops, such as maize, rice, and cassava. Moreover, the scheme has allowed farmers to improve their market access by enhancing the efficiency of their production (Mpogole, 2020). However, some farmers have faced repayment difficulties due to fluctuating incomes, leading to the financial instability of the program. Additionally, a lack of financial literacy among farmers has led to challenges in understanding loan terms and managing credit (Mpogole, 2020). Zimbabwe could consider replicating Tanzania's model and incorporate financial literacy training to help farmers manage loans effectively. A diversified loan package that accommodates different income levels and agricultural cycles could also improve repayment rates.

Ethiopia's Agricultural Transformation Agency (ATA) has implemented a comprehensive strategy to promote mechanization through subsidies, training programs, and local manufacturing of machinery. ATA's approach focuses on reducing the cost of equipment for smallholder farmers by providing subsidies on tractors, plows, and other essential machinery. In addition to subsidies, ATA also provides training to farmers on how to use mechanized equipment and maintain it properly. Furthermore, the program encourages local machinery manufacturing to create affordable equipment that meets the specific needs of Ethiopian farmers. This multi-faceted approach has led to a significant increase in the use of modern agricultural equipment among Ethiopian farmers, improving their productivity. Smallholder farmers have reported a reduction in labor costs and increased efficiency in land preparation and harvesting (Houmy *et al*., 2013). Local manufacturing has also created jobs and contributed to the development of the agricultural machinery sector in Ethiopia. Despite the successes, the Ethiopian program faces some barriers, including limited availability of spare parts for locally manufactured equipment and occasional issues with the quality of machinery. Moreover, the program's reliance on subsidies has raised concerns about its sustainability over the long term (Houmy *et al*., 2013). Zimbabwe could learn from Ethiopia's subsidy model and integrate local machinery production to meet the specific needs of its smallholder farmers. However, there must be a focus on the sustainability of subsidies, including the development of supply chains for spare parts and maintenance services.

Zimbabwe's Tractorization Scheme, launched in the 1980s, has been a central component of the country's agricultural mechanization efforts. The scheme provided subsidized tractors to smallholder farmers through various government and private sector initiatives. Over the years, however, the effectiveness of the scheme has been debated, with mixed results reported in terms of its impact on smallholder productivity. According to a case study conducted by the Zimbabwe Agricultural Development Authority (ZADA), the tractorization scheme led to improvements in crop yields and income levels for farmers who adopted mechanization. The availability of tractors helped increase land cultivation and improved timeliness in planting and harvesting (Baudron *et al*., 2019). However, several challenges have been identified. Maintenance and spare parts availability have been problematic, as tractors have sometimes been left idle due to mechanical failures. Access to finance remains a significant barrier for many smallholder farmers, as not all farmers can afford to participate in the scheme. Additionally, inefficiencies in the management of the tractor pool system and political interference have hindered the program's effectiveness (Baudron *et al*., 2019). A detailed analysis of the tractorization scheme could provide critical insights into its successes and limitations. Data comparing crop yields, income levels, and mechanization adoption between participants and non-participants could inform future policy

decisions. For instance, integrating financial support for farmers to cover maintenance costs and enhancing transparency in the management of tractor hiring services could increase the scheme's success.

Through analyzing the successes and challenges of mechanization programs in Malawi, Tanzania, Ethiopia, and Zimbabwe's own tractorization scheme, Zimbabwe can adopt a more effective approach to mechanizing its agricultural sector. Key recommendations for Zimbabwe include strengthening public-private partnerships (PPPs) to increase the availability of mechanized services, expanding credit facilities and subsidy programs to enable more smallholder farmers to afford modern machinery, developing training programs to ensure farmers can effectively use and maintain mechanized equipment, fostering local machinery manufacturing to reduce costs and create jobs, and incorporating sustainability mechanisms into subsidy and credit programs to ensure long-term effectiveness. By learning from the experiences of other African nations and addressing the challenges faced by previous programs, Zimbabwe can refine its mechanization strategies to maximize agricultural productivity and support smallholder farmers.

Conclusion

Agricultural mechanization in Zimbabwe is not merely about introducing machinery; it is a transformative strategy to enhance productivity, improve livelihoods, and strengthen food security. However, the sector faces critical challenges, including financial constraints, inadequate infrastructure, and limited access to equipment maintenance services, particularly for smallholder farmers. Addressing these barriers is essential for unlocking the full potential of mechanization. The findings of this study highlight the significant opportunities for Zimbabwe to advance mechanization through targeted policies, investment in infrastructure, and innovative financing mechanisms. Furthermore, coupling mechanization with climate-smart agricultural practices not only enhances resource efficiency but also mitigates environmental impact and strengthens resilience to climate challenges. By prioritizing sustainability, mechanization can serve as a long-term solution rather than a short-term fix. These insights underscore the need for policies that ensure equitable access to mechanization, especially for marginalized farming communities. A well-structured mechanization strategy can drive economic growth while promoting environmental sustainability and social inclusion.

However, challenges such as the high costs of equipment, knowledge gaps, and policy inconsistencies remain hurdles that require urgent attention. A key limitation of this study is the scope of available data on smallholder mechanization adoption, particularly in remote rural areas. Future research should focus on assessing the effectiveness of existing mechanization programs, identifying scalable solutions for resource-poor farmers, and exploring the role of public-private partnerships in expanding mechanization services. Looking ahead, further research should explore the long-term economic and environmental impacts of mechanization in Zimbabwe, as well as the role of emerging technologies such as precision agriculture and automation in enhancing efficiency. Investigating sustainable financing models tailored to smallholder farmers will also be crucial for widespread adoption. In conclusion, mechanization holds the potential to revolutionize Zimbabwe's agricultural sector, but its success depends on well-designed policies, inclusive implementation strategies, and sustainable practices. A coordinated effort by policymakers, researchers, and industry stakeholders is essential to ensure that mechanization not only boosts productivity but also contributes to a resilient and sustainable agricultural future for Zimbabwe.

Recommendations

To unlock the full potential of agricultural mechanization in Zimbabwe, targeted

strategies must address key barriers while promoting sustainability and inclusivity. The following recommendations provide a framework for action:

Develop a comprehensive mechanization policy

A national policy should prioritize smallholder farmers, integrate evidence-based strategies, and align with economic, social, and environmental objectives. This policy should ensure coordination among stakeholders and provide a clear roadmap for mechanization initiatives (Moyo, 2014).

Enhance access to affordable financing

Smallholder farmers require tailored credit facilities, including micro-financing, leasing options, and low-interest loans with minimal collateral requirements. Strengthening financial inclusion through public-private partnerships (PPPs) and specialized agricultural banks can improve mechanization adoption (Chigunhah *et al*., 2020).

Support local manufacturing and assembly

Investing in local manufacturing hubs for machinery and spare parts can reduce dependence on imports, lower equipment costs, and create employment. Incentives such as tax breaks, grants, and subsidies should be introduced to attract investment in domestic mechanization industries (Mujeyi *et al*., 2015).

Promote climate-resilient mechanization

Mechanization strategies must incorporate climate-smart technologies, such as conservation tillage implements, solar-powered irrigation, and low-emission tractors. These investments will enhance productivity while ensuring environmental sustainability (Ndlovu *et al*., 2020).

Strengthen training and capacity building

Effective mechanization adoption requires robust training programs for farmers, extension officers, and technicians. This includes hands-on training in equipment operation, maintenance, and repair, as well as digital literacy for accessing precision agriculture tools (Mukembo & Edwards, 2015).

Leverage public-private partnerships (PPPs)

Successful mechanization initiatives in Zambia and Ethiopia demonstrate the value of PPPs in mobilizing resources, financing mechanization hubs, and developing mechanization service centers. Zimbabwe should adopt similar models to enhance access to equipment and technical support (Arslan *et al*., 2020).

Improve mechanization infrastructure

Developing rural infrastructure, such as roads, storage facilities, and service centers, will enhance the accessibility and sustainability of mechanization efforts, reducing costs and improving efficiency for farmers (Mujeyi *et al*., 2015).

Future Research

Future research on agricultural mechanization in Zimbabwe should focus on addressing critical gaps that hinder adoption and sustainability. One key area of investigation should be the socio-economic impact of mechanization on smallholder farmers. Understanding how mechanization affects productivity, income levels, labor requirements, and rural development will provide valuable insights for designing inclusive policies. Additionally, there is a need to examine regional disparities in mechanization adoption to develop location-specific interventions. Another crucial research area involves developing and accessing innovative financing models tailored to the unique needs of smallholder farmers in Zimbabwe. While access to credit remains a significant barrier, exploring alternative financing options such as microcredit, group leasing schemes, and subsidy-based programs can help improve affordability. Comparative studies assessing the effectiveness of these models in similar African contexts will offer practical recommendations for Zimbabwe's financial sector. The feasibility of local manufacturing and assembly of agricultural machinery and spare parts is another area that

requires in-depth research. Evaluating the economic viability, supply chain dynamics, and necessary policy incentives to support local production will determine whether Zimbabwe can reduce its dependence on imported equipment and create local employment opportunities. Additionally, research should assess the effectiveness of agricultural extension services in facilitating mechanization adoption. Farmers' ability to use and maintain equipment effectively is directly linked to the quality of training and advisory services they receive. Studies should explore whether current extension programs are adequately equipping farmers with the necessary technical skills and knowledge, identifying areas for improvement. The long-term sustainability and environmental impact of mechanization is also a critical research priority. Future studies should examine the ecological consequences of increased mechanization, focusing on soil health, water usage, and carbon emissions. This will help policymakers develop guidelines that balance productivity gains with environmental conservation. Moreover, assessing the life cycle of mechanized equipment and the role of local communities in ensuring regular maintenance will provide insights into how to sustain mechanization efforts over time. Finally, the role of emerging technologies such as precision agriculture, automation, and artificial intelligence in enhancing mechanization efficiency should be explored. With advancements in digital tools, understanding how these technologies can be integrated into Zimbabwe's agricultural systems will be crucial for future development. Research should investigate their accessibility, affordability, and effectiveness in improving productivity for smallholder farmers.

Acknowledgments

The authors thank Lupane State university for enabling access to e-resources and facilities during this study.

Conflict of Interest

The authors declare no conflict of interest.

Authors Contribution

B. Chisadza: Conceptualization, Methodology, Visualisation, Writing – Original Draft, Review & Editing

A. Mugoti: Conceptualisation, Technical Advice, Data Acquisition, Review & Editing

S. Chinomona: Methodology, Technical Advice, Data Acquisition, Review & Editing

D. Nyathi: Supervision, Conceptualization, Policy Analysis, Writing – Review & Editing, Validation

References

1. African Development Bank (AfDB). (2023). Malawi agricultural mechanization impact evaluation report. https://www.afdb.org/en/search/content/malawimechanisationreport
2. Arslan, A., Floress, K., Lamanna, C., Lipper, L., Asfaw, S., & Rosenstock, T. (2020). IFAD Research Series 63–The Adoption of Improved Agricultural Technologies: A Meta-Analysis for Africa. *IFAD Research Series*. https://doi.org/10.2139/ssrn.3681375
3. Baudron, F., Nazare, R., & Matangi, D. (2019). The role of mechanization in transformation of smallholder agriculture in Southern Africa: experience from Zimbabwe. In *Transforming Agriculture in Southern Africa* (pp. 152-160). Routledge. https://doi.org/10.4324/9780429401701
4. Chambati, W. (2013). Changing agrarian labour relations after land reform in Zimbabwe. *Land and Agrarian Reform in Zimbabwe: Beyond White-Settle Capitalism*, 157-194. https://www.academia.edu/download/87611542/ae4aa9839ee54501beeceb8d2a8bd22619c2.pdf
5. Chigunhah, B. R., Svotwa, E., Mabvure, T. J., Munyoro, G., & Chikazhe, L. (2020). The status of agricultural financing by commercial banks in Zimbabwe. *APSTRACT: Applied Studies in Agribusiness and Commerce*, *14*, 45-56. https://doi.org/10.22004/ag.econ.339762

6. Chimonyo, V., Baudron, F., & Matangi, D. (2023). Appropriate farm scale mechanization can aid in agroecological transformation. *CGIAR*. https://hdl.handle.net/10568/135121
7. Chinsinga, B. (2018). The Political Economy of Agricultural Commercialisation in Malawi. *APRA Working Paper, 17*. https://www.cabidigitallibrary.org/doi/full/10.5555/20193145060
8. Daum, T., & Birner, R. (2020). Agricultural mechanization in Africa: Myths, realities, and an emerging research agenda. *Global Food Security, 26*, 100393. https://doi.org/10.1016/j.gfs.2020.100393
9. FAO & AUC. (2019). Sustainable Agricultural Mechanization: A Framework for Africa-Synopsis. Addis Ababa. https://openknowledge.fao.org/server/api/core/bitstreams/c610a6b7-47fd-4b40-8cf7-e66dfd892735/content
10. FAO. (2019). The State of Food Security and Nutrition in the World 2019. https://openknowledge.fao.org/server/api/core/bitstreams/16480532-17e9-4b61-b388-1d6d86414470/content
11. Food and Agriculture Organization (FAO). (2008). *Agricultural mechanization in Africa...Time for action*. Food and Agriculture Organization of the United Nations. https://www.fao.org/4/k2584e/k2584e.pdf
12. Food and Agriculture Organization of the United Nations (FAO). (2014). *The state of food and agriculture 2014: Innovation in family farming.* FAO. https://openknowledge.fao.org/server/api/core/bitstreams/f6b32ac3-74c8-4c4b-ac6b-60a21d74202f/content
13. Food and Agriculture Organization of the United Nations (FAO). (2018). The state of food security and nutrition in the world 2018: Building climate resilience for food security and nutrition. FAO. https://openknowledge.fao.org/server/api/core/bitstreams/f5019ab4-0f6a-47e8-85b9-15473c012d6a/content
14. Gopalakrishnan, P., & Banerji, A. K. (2013). *Maintenance and spare parts management*. PHI Learning Pvt. Ltd. https://content.kopykitab.com/ebooks/2017/09/11832/sample/sample_11832.pdf
15. Government of Zimbabwe. (2015). Mechanization and Irrigation Development Fund. Accessed on 04 January 2025. https://www.agric.gov.zw/wordpress/?page_id=6475
16. Houmy, K., Clarke, L. J., Ashburner, J. E., & Kienzle, J. (2013). *Agricultural mechanization in sub-Saharan Africa: Guidelines for preparing a strategy* (Integrated Crop Management, Vol. 22). Food and Agriculture Organization of the United Nations. https://www.fao.org/4/i3349e/i3349e.pdf
17. International Food Policy Research Institute (IFPRI). (2020). In search of effective support for agricultural mechanization in Africa. IFPRI. https://www.ifpri.org/blog/search-effective-support-agricultural-mechanization-africa/
18. International Fund for Agricultural Development (IFAD). (2019). *Rural development report 2019: Creating opportunities for rural youth.* IFAD. https://www.ifad.org/en/w/publications/2019-rural-development-report
19. International Trade Administration. (2023). *Zimbabwe - Agricultural Sectors*. Retrieved from https://www.trade.gov/country-commercial-guides/zimbabwe-agricultural-sectors
20. Kang'ethe, S. M., & Serima, J. (2014). Exploring challenges and opportunities embedded in small-scale farming in Zimbabwe. *Journal of Human Ecology*, *46*(2), 177-185. https://www.cabidigitallibrary.org/doi/full/10.5555/20143253649
21. Kienzle, J., & Sims, B. G. (2014). Agricultural mechanization strategies for sustainable production intensification: Concepts and cases from (and for) sub-Saharan Africa. *FAO, Rome*. https://www.clubofbologna.org/ew/documents/3_1b_KNR_Kienzle_mf.pdf
22. Kiptot, E., & Franzel, S. (2014). Voluntarism as an investment in human, social, and financial

capital: Evidence from a farmer-to-farmer extension program in Kenya. *Agriculture and Human Values*, *31*(2), 231-243. https://doi.org/10.1007/s10460-013-9463-5

23. Koech, B. J. (2022). Stakeholder engagement and implementation of agricultural mechanization initiatives: A case of tea harvesting machines project at Kaptumo Tea Factory, Nandi County, Kenya (Doctoral dissertation, University of Nairobi). https://erepository.uonbi.ac.ke/handle/11295/162347
24. Madzivanzira, T., Mvumi, B. M., Nazare, R. M., Nyakudya, E., Mtambanengwe, F., & Mapfumo, P. (2024). A review of appropriate mechanisation systems for sustainable traditional grain production by smallholder farmers in sub-Saharan Africa with particular reference to Zimbabwe. *Heliyon*. https://doi.org/10.1016/j.heliyon.2024.e36695
25. Makonese, M. A. K. A. N. A. T. S. A. (2017). The Policy and Legislative Framework for Zimbabwe's Fast Track Land Reform Programme and its Implications on Women's Rights to Agricultural Land (Doctoral dissertation, PhD Thesis, Southern and East African Regional Centre for Women's Law (SEARCWL) University of Zimbabwe). https://searcwl.ac.zw/wp-content/uploads/2023/09/PhD-Thesis_Final_Makanatsa-Makonese_4-September-2017.pdf
26. Mango, N., Siziba, S., & Makate, C. (2017). The impact of adoption of conservation agriculture on smallholder farmers' food security in semi-arid zones of southern Africa. *Agriculture & Food Security*, *6*, 1-8. https://doi.org/10.1186/s40066-017-0109-5
27. Masawe, J. (1994). Agricultural credit as an instrument of rural development in Tanzania: A case study on the credit programme for tractorization of small scale agriculture in Morogoro region. *African Study Monographs*, *15*(4), 211-226. https://doi.org/10.14989/68125
28. Mhembwe, S., Chiunya, N., & Dube, E. (2019). The contribution of small-scale rural irrigation schemes towards food security of smallholder farmers in Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *11*(1), 1-11. https://doi.org/10.4102/jamba.v11i1.674
29. Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement. (2019). *National agricultural extension strategy framework (2019–2030)*. Government of Zimbabwe. https://www.harvestplus.org/wp-content/uploads/2021/12/Zimbabwe_NAPF_2019-2030.pdf
30. Mkodzongi, G., & Lawrence, P. (2019). The fast-track land reform and agrarian change in Zimbabwe. *Review of African Political Economy*, *46*(159), 1-13. https://doi.org/10.1080/03056244.2019.1622210
31. Moyo, S. (2014). Changing agrarian relations after redistributive land reform in Zimbabwe. In *Outcomes of Post-2000 Fast Track Land Reform in Zimbabwe* (pp. 33-60). Routledge. https://doi.org/10.4324/9781315873275
32. Mpogole, H., Dimoso, P., & Mayaya, H. (2020). Agriculture for Rural Development in Tanzania. TEMA Publishers Co. Limited, Dar es Salaam.
33. Muhwezi, D. K. (2003). Gender-sensitive educational policy and practice: Uganda case study. International Bureau of Education. https://unesdoc.unesco.org/ark:/48223/pf0000146783
34. Mujeyi, K., Mutambara, J., Siziba, S., Sadomba, W. Z., & Manyati, T. K. (2015). Entrepreneurial innovations for agricultural mechanisation in Zimbabwe: Evidence from an informal metal industry survey. *African Journal of Science, Technology, Innovation and Development*, *7*(4), 276-285. https://hdl.handle.net/10520/EJC180821
35. Mukembo, S. C., & Edwards, C. M. (2015). Agricultural extension in Sub-Saharan Africa during and after its colonial era: The case of Zimbabwe, Uganda, and Kenya. *Journal of International Agricultural and Extension Education*, *22*(3), 50-68. https://doi.org/10.5191/jiaee.2015.22304
36. Musabanganji, E., Antoine, K., & Lebailly, P. (2015, November). Determinants of access to agricultural credits for small-scale farmers in the Southern Province of Rwanda. In *6th International Scientific Agriculture Symposium "AgroSym 2015"*. https://hdl.handle.net/2268/190058

37. Ndlovu, E., Prinsloo, B., & Le Roux, T. (2020). Impact of climate change and variability on traditional farming systems: Farmers' perceptions from south-west, semi-arid Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *12*(1), 1-19. https://hdl.handle.net/10520/ejc-jemba-v12-n1-a9
38. Ngissah, E. (2023). Uberisation of Mechanisation; What are the Features of And Constraints to the functionality of matchmaker Tractor Hire Platforms in Ghana? (MSc Thesis). https://edepot.wur.nl/642128
39. Ngoma, H., Simutowe, E., & Thierfelder, C. (2023). Challenges and opportunities to scaling smallholder mechanization in Kenya, Malawi, Zambia, and Zimbabwe. https://cgspace.cgiar.org/bitstreams/0b903807-b9cf-4fac-b357-b577d9327dbb/download
40. Ngoma, H., Simutowe, E., Md Abdul Matin., & Thierfelder, C. (2023). Challenges and opportunities to scaling smallholder mechanization in Kenya, Malawi, Zambia, and Zimbabwe. CIMMYT. https://hdl.handle.net/10883/22978
41. Ngwarati, T. T. (2024). Mechanization and import substitution in Zimbabwean farmers 'equipment: a case study of the revitalization of an abandoned tractor trailer. *I-manager's Journal on Mechanical Engineering*, *14*(2). https://doi.org/10.26634/jme.14.2.20386
42. Nyamangara, J., Masvaya, E. N., Tirivavi, R., & Nyengerai, K. (2013). Effect of hand-hoe based conservation agriculture on soil fertility and maize yield in selected smallholder areas in Zimbabwe. *Soil and Tillage Research*, *126*, 19-25. https://doi.org/10.1016/j.still.2012.07.018
43. Olaoye, O. A. (2014). Potentials of the agro industry towards achieving food security in Nigeria and Other Sub-Saharan African Countries. *Journal of Food Security*, *2*(1), 33-41. https://pubs.sciepub.com/jfs/2/1/5/
44. Pingali, P. (2007). Agricultural mechanization: adoption patterns and economic impact. *Handbook of Agricultural Economics*, *3*, 2779-2805. https://doi.org/10.1016/S1574-0072(06)03054-4
45. Scoones, I., Marongwe, N., Mavedzenge, B., Mahenehene, J., Murimbarimba, F., & Sukume, C. (2010). *Zimbabwe's land reform: myths & realities*. Oxford: James Currey. http://www.ids.ac.uk/files/dmfile/zimbabwean5pdf.pdf
46. Shonhe, T. (2019). Tractors and agrarian transformation in Zimbabwe: Insights from Mvurwi. *APRA Working Paper*, *21*. https://www.cabidigitallibrary.org/doi/full/10.5555/20193145064
47. Shonhe, T., Scoones, I., & Murimbarimba, F. (2020). Medium-scale commercial agriculture in Zimbabwe: The experience of A2 resettlement farms. *The Journal of Modern African Studies*, *58*(4), 601-626. https://doi.org/10.1017/S0022278X20000385
48. Sims, B., & Kienzle, J. (2017). Sustainable agricultural mechanization for smallholders: What is it and how can we implement it? *Agriculture*, *7*(6), 50. https://doi.org/10.3390/agriculture7060050
49. Simutowe, E., Chikwalila, E. M., Chipindu, L., Tufa, A. H., Alene, A. D., Matin, M. A., ... & Ngoma, H. (2023). Status of appropriate-scale mechanization in Zambia and Zimbabwe. A report produced for the ACASA project and the CGIAR Regional Initiative, Ukama Ustawi: Diversification in East and Southern Africa. https://cgspace.cgiar.org/bitstreams/faaa9ce4-eb0e-4a46-a6f2-3d83e83293af/download
50. Singh, Y., Sidhu, H. S., Jat, H. S., Singh, M., Chhokar, R. S., Setia, R., & Jat, M. L. (2020). Conservation agriculture and scale of appropriate agricultural mechanization in smallholder systems. *Journal of Sustainable Agriculture*, *42*(2), 149-164. https://agris.fao.org/search/en/providers/123818/records/67235a93b605bda15e0a8a56
51. Stamborowski, I. (2023). Finance Models to Enable Small Farmers to Afford New Technologies, (doctoral theses). https://www.politesi.polimi.it/handle/10589/223836
52. The Herald. (2024). *Zimbabwe: U.S.$600m irrigation developments in pipeline*. Retrieved

February 2025, from https://allafrica.com/stories/202407040433.html
53. Thierfelder, C., Baudron, F., Setimela, P., Nyagumbo, I., Mupangwa, W., Mhlanga, B., ... & Gérard, B. (2018). Complementary practices supporting conservation agriculture in southern Africa. A review. *Agronomy for Sustainable Development*, *38*, 1-22. https://doi.org/10.1007/s13593-018-0492-8
54. Üllenberg, A., Minah, M., Rauch, T., & Richter, D. (2017). *Zambia: Towards Inclusive and Sustainable Rural Transformation*. Albrecht Daniel Thaer-Institut für Agrar-und Gartenbauwissenschaften. https://edoc.hu-berlin.de/bitstream/handle/18452/18672/4.pdf?sequence=1
55. United Nations (UN). (2019). *Mechanizing agriculture is key to food security*. Africa Renewal, United Nations. https://africarenewal.un.org/en/magazine/mechanizing-agriculture-key-food-security
56. Wanjiku, J., Manyengo, J. U., Oluoch-Kosura, W., & Karugia, J. T. (2007). Gender differentiation in the analysis of alternative farm mechanization choices on small farms in Kenya. In *Food insecurity, vulnerability and human rights failure* (pp. 194-218). Palgrave Macmillan UK. https://doi.org/10.1057/9780230589506_8
57. Zimbabwe National Statistics Agency. (2019). Zimbabwe Agricultural Survey 2019. https://nada.zimstat.co.zw/index.php/catalog/81/download/415

مکانیزاسیون در کشاورزی خرده‌مالکان زیمبابوه: چالش‌ها، فرصت‌ها و مسیرهای سیاست‌گذاری از زمان اصلاحات ارضی

برایت چیسادزا[۱]، آلبان موگوتی[۲*]، سایلِنس چینومونا[۱]، داگلاس نیاتی[۳]

تاریخ دریافت: ۱۴۰۴/۰۱/۰۹
تاریخ پذیرش: ۱۴۰۴/۰۴/۱۶

چکیده

مکانیزاسیون کشاورزی محرک حیاتی بهره‌وری، امنیت غذایی و کشاورزی پایدار در زیمبابوه و مناطق مختلف جهان است. در سراسر چشم‌اندازها و سیستم‌های کشاورزی متنوع در جهان، قدرت تحول‌آفرین آن به‌طور فزاینده‌ای به‌عنوان امری ضروری برای برآورده کردن نیازهای رو به رشد غـذایی و تقویت اقتصادهای روستایی مقاوم شناخته می‌شود. با این وجود، کشاورزان خرده‌مالک با موانع متعددی برای مکانیزاسیون مواجه هستند که توانایی آن‌ها را در بهره‌مندی کامل از فناوری‌های مدرن کشاورزی محدود می‌کند. در دوران پس از اصلاحات ارضی، ناکارآمدی‌های سیستمی، نابرابری‌های مداوم و حمایت ناکافی نهادها، این چالش‌ها را تشدید کرده است. این مطالعه یک بررسی مروری روایـی، بـا پشـتیبانی از تکنیک‌هـای هدفمنـد، بـرای ترکیـب داده‌های نشریات داوری شده، گزارش‌های سیاست‌گذاری و اسناد نهادی (۲۰۲۴–۲۰۰۰) است. منابع از طریق جستجوی کلمـات کلیـدی در Google Scholar، Scopus و ادبیات خاکستری شناسایی شدند و از تحلیل موضوعی برای استخراج موانـع و فرصـت‌ها در چشـم‌انداز مکانیزاسـیون زیمبـابوه استفاده شد. یافته‌های کلیدی نشان می‌دهد که در حال حاضر تنها ۱۲٪ از کشاورزان خرده‌پا در زیمبابوه از تراکتور استفاده می‌کنند، در حالی‌کـه ۸۰٪ از کشاورزان بزرگ از تراکتور استفاده می‌کنند. مکانیزاسیون پتانسیل دو برابر کردن بازده محصول را دارد، که با افزایش ۱۰۰٪ بهره‌وری در زیمبـابوه و تـا ۱۵۰٪ در کشورهای مشابه مشهود است. با این حال، نابرابری‌های منطقه‌ای همچنان شدید است، به‌طوری‌که نـرخ مکانیزاسـیون از ۵ تـا ۱۵ درصـد در استان‌های خشک مانند ماتابلند جنوبی تا بیش از ۵۰٪ در مناطق پربارتر مانند ماشونالند غربی متغیر است. با وجـود ایـن چالش‌هـا، فرصـت‌هایی بـرای پیشبرد مکانیزاسیون از طریق مراکز تولید محلی، فناوری‌های مقاوم در برابر آب و هوا و مدل‌های تامین مالی نوآورانه وجود دارد. این مطالعه بـا بررسـی مقایسه‌ای ابتکارات موفق مکانیزاسیون در سایر کشورهای آفریقایی، استراتژی‌های عملی مانند بهبود انسجام سیاست‌ها، گسترش گزینه‌های تامین مالی مقرون به صرفه و تقویت مشارکت‌های دولتی و خصوصی را برجسته می‌کند.

واژه‌های کلیدی: امنیت غذایی، بهره‌وری کشاورزی، فناوری‌های مقاوم در برابر آب و هوا، کشاورزی حفاظتی، کشاورزان خرده‌پا

۱- گروه علوم زراعی و علوم خاک، دانشکده علوم کشاورزی، دانشگاه دولتی لوپانه، لوپانه، زیمبابوه
۲- گروه علوم دامی و مدیریت مراتع، دانشکده علوم کشاورزی، دانشگاه دولتی لوپانه، لوپانه، زیمبابوه
۳- دانشکده مدیریت عمومی، حکمرانی و سیاست‌گذاری عمومی، دانشگاه ژوهانسبورگ، گائوتنگ، آفریقای جنوبی
(*- نویسنده مسئول: Email: amugoti@lsu.ac.zw)

https://doi.org/10.22067/jam.2025.92819.1362