

# **THESIS**

**LUHENDE DANIEL JITUNGULU**

**BSc. Agricultural Engineering**

**Gödöllő**

**2025**



**Hungarian University of Agriculture and Life Sciences**

**Szent István Campus**

**B.Sc. Agricultural Engineering**

**ANALYSIS OF MECHANIZED AGRICULTURE IN TANZANIA. A CASE STUDY OF  
HUMAN, ANIMAL, AND MACHINERY POWER SOURCES IN SHINYANGA  
REGION**

<b>Supervisor:</b>	Bártfai Zoltán Ph.D. Assistant Professor
<b>Author:</b>	Luhende Daniel Jitungulu YJG400
<b>Institute:</b>	Institute of Agronomy

**Gödöllő**

**2025**

## TABLES OF CONTENTS

<b>TABLES OF CONTENTS</b> .....	1
<b>CHAPTER 1: INTRODUCTION</b> .....	4
1.1 Background of the study .....	4
1.2 Statement of the problem .....	5
1.3 Objectives of the study.....	6
1.4 Research questions.....	7
1.5 Significance of the study.....	6
1.6 Scope and limitations.....	6
<b>CHAPTER TWO: LITERATURE REVIEW</b> .....	7
2.1. Introduction to agricultural mechanization in Tanzania: a foundational perspective .....	8
2.1.1 The pivotal role of agriculture in Tanzania’s socio-economic landscape .....	8
2.1.2. Defining agricultural mechanization: A spectrum of power sources .....	8
2.1.3. The Imperative of mechanization for food security and economic prosperity.....	9
2.1.4. The shinyanga region: A case study in the broader Tanzanian agricultural context.....	10
2.2. Human power sources in tanzanian agriculture: the enduring foundation.....	11
2.2.1. Pervasiveness and traditional modalities of manual labor .....	11
2.2.2. Inherent challenges and limiting factors of human labor .....	12
2.2.3. Disproportionate Gendered Impacts of Manual Labor .....	12
2.2.4. Complex Interactions between Human Labor and Other Power Sources .....	13
2.3. Draught animal power (DAP) in tanzania: a transitional technology .....	13
2.3.1. Historical trajectories and policy imperatives for oxenization .....	13
2.3.2. Operational Advantages of Draught Animal Power: Area Cultivation and Labor Productivity...	14
2.3.3. Persistent Limitations and Barriers to Widespread DAP Adoption.....	15
2.3.4. Illuminating Case Studies and Transferable Lessons from East African Experiences .....	15
2.4. Mechanical Power Sources in Tanzanian Agriculture: The Path to Modernization .....	16
2.4.1. Comprehensive Overview of Mechanical Technologies in Use .....	16
2.4.2. Profound Impact on Land Preparation and Cultivation Practices .....	17
2.4.2.1. Direct Substitution of Manual and Animal Labor.....	17
2.4.2.2. Enhanced Efficiency and Critical Timeliness of Operations .....	17
2.4.2.3. Specialized Benefits for Rice Farming: The Role of Puddling with 2WTs .....	17

2.4.3. Mechanization, Intensification, and Extensification: A Deeper Dive.....	18
2.4.3.1. Agricultural Intensification: Driving Yield-Enhancing Technologies.....	18
2.4.3.2. Agricultural Extensification: Expanding the Cultivated Frontier .....	18
2.4.3.3. Differentiated Impacts of 4WTs and 2WTs on Intensification and Extensification .....	18
2.4.4. Labor Dynamics and Employment Implications of Mechanization.....	19
2.4.4.1. Reduction in Direct Family Labor Use .....	19
2.4.4.2. Increased Demand for Hired Labor.....	19
2.4.4.3. Historical Concerns and Contemporary Debates on Unemployment .....	20
2.5. Comparative analysis of power sources in shinyanga region's context: an integrated perspective .	20
2.5.1. Synergies and complementarities across power sources.....	20
2.6. Conclusion .....	21
2.6.1. Synthesis of key findings .....	21
2.6.2. Identified gaps in research and the imperative for region specific studies .....	22
<b>CHAPTER 3: METHODOLOGY.....</b>	<b>22</b>
3.1 Research design .....	22
3.2 Study area.....	23
3.3 Population and sampling.....	25
3.4 Data collection methods.....	26
3.5 Data analysis .....	28
3.6 Ethical considerations .....	28
<b>CHAPTER 4: RESULTS AND DISCUSSION .....</b>	<b>30</b>
4.1 Overview of power sources usage .....	30
4.1.1 Distribution by agro-ecological zones .....	31
4.2 Efficacy of human power sources .....	32
4.3 Usage and effect of draught animal power .....	32
4.4 Impact of mechanical power sources .....	33
4.5 Comparative analysis .....	34
<b>CHAPTER 5: CONCLUSION AND RECOMMENDATION.....</b>	<b>36</b>
5.1 Conclusions.....	36
5.2 Recommendations.....	38
<b>CHAPTER 6: SUMMARY .....</b>	<b>39</b>
<b>7. ACKNOWLEDGEMENTS.....</b>	<b>41</b>
<b>8. BIBLIOGRAPHY .....</b>	<b>42</b>

<b>LIST OF TABLES.....</b>	<b>49</b>
<b>LIST OF FIGURES.....</b>	<b>50</b>
<b>9.APPENDICES .....</b>	<b>51</b>
<b>10. DECLARATIONS .....</b>	<b>55</b>

## **CHAPTER 1: INTRODUCTION**

### **1.1 Background of study**

The economy of Tanzania is based on agriculture, which employs more than 65 percent of the population and contributes about 28 percent to the national Gross Domestic Product (GDP). Agriculture in the Shinyanga Region, which is a part of the northwestern part of Tanzania, is mainly subsistence-based, with crops such as cotton, maize, and rice being the dominant features of the land, as well as the fact that livestock rearing is a significant contributor to food production and economic activities in the region (National Bureau of Statistics [NBS], 2022). The semi-arid climate and large arable land area of approximately 50,000 square kilometers offer unique opportunities to use mechanization, but the traditional farming practices that are based on human and animal labor are still present because of the historical and infrastructural factors (FAO 2021, 2021). It has been noted that mechanized agriculture, which refers to the combination of non-human sources of power, including animals and machinery, to boost the efficiency of farming, is one of the factors that have contributed to the transformation of the rural economies of developing nations such as Tanzania (Binswanger-Mkhize & Savastano, 2017).

The development of power sources in the Tanzanian agriculture dates back to colonialism when draught animal power (DAP) was used to complement manual work in areas with an appropriate population of livestock (Mrema et al., 2008). The Sukuma ethnic group in Shinyanga has been using oxen to plow their fields since the culture has adapted to the agro-ecological environment in the area (Shetto & Owenya, 2007). Nevertheless, the post-independence period witnessed occasional government efforts to bring mechanical power, including tractors, that were usually unsuccessful because of the maintenance problems and the absence of spare parts (Lugendo et al., 2016). The latest policies within the Agricultural Sector Development Programme (ASDP) in Tanzania focus on mechanization as the means to attain food security and poverty reduction, which is consistent with the Sustainable Development Goals (SDGs), especially SDG 2 on zero hunger (United Republic of Tanzania [URT], 2019). Nevertheless, machinery adoption is still low at approximately 13 percent in the country and Shinyanga has a higher DAP adoption but fewer tractor penetration.

Smallholder farms in Shinyanga are dominated by human power, which entails manual labor, such as hoes and machetes, since family labor is the main source of input to perform activities such as

planting and weeding (Nakano & Magezi, 2019). This dependence is due to the economic limitation and the topography of the area, which consists of flat plains that can be cultivated manually but difficult to use large machinery (Namiotko et al., 2022). Animal power, especially oxen, has been adopted in cotton producing regions, which has helped farmers to farm more land and enhance time efficiency of activities (Starkey & Mutagubya, n.d.). Machinery, such as two-wheel tractors (2WTs) and four-wheel tractors (4WTs) are the epitome of modernization, but their contribution in Shinyanga is disproportionate because it is expensive and relies on fuel (Magezi et al., 2023). The interaction of these sources of power is important in the development of policies in the region where agriculture employs more than 80 percent of the population (NBS, 2022).

## **1.2 Statement of the problem**

Although Tanzania has a huge agricultural potential, 45 million hectares of arable land, the productivity of staple crops is low at approximately 1.5 tons per hectare, which is significantly lower than the world averages (FAO, 2021). This problem is aggravated in Shinyanga by the use of inefficient sources of power, which results in labor-intensive activities that cause soil erosion and low productivity (Hoyk et al., 2022). Human power, though available, causes high levels of drudgery and restricts farmland to a 2-3 hectares per household average, which continues the cycles of poverty (Teca, 2026). Draught animal power is somewhat alleviated but limited by such diseases as trypanosomiasis caused by tsetse flies, which impacts the health of livestock and makes it less effective in approximately 60% of the area (Mrema, 2016a).

Mechanization of power sources has been encouraged, such as the National Mechanization Strategy, but in Shinyanga, barriers such as poor infrastructure have prevented its adoption, and only 10% of farmers have hired tractors through hiring services (Lugendo et al., 2016). The result of this mismatch is untimely operations, losses of more than 30 percent after harvesting, and exposure to climate variability (URT, 2021). Current literature concentrates on national trends, and there is a gap in the region-specific studies of the impact of human, animal, and machinery sources of power on productivity and livelihoods (Magezi et al., 2023,). In the absence of specific research, policies might not respond to the specific issues of Shinyanga including the high density of livestock and semi-arid climate that may impede sustainable agricultural development (JAICAF, 2015). Furthermore, gender disparities amplify the problem, as women, who constitute 60% of the agricultural workforce in Shinyanga, bear the brunt of manual labor, limiting their

economic empowerment (Alliance for a Green Revolution in Africa [AGRA], 2020). The lack of comprehensive data on the efficacy and impacts of these power sources results in inefficient resource allocation, with government subsidies often benefiting larger farms rather than smallholders. Addressing this requires an in-depth case study to evaluate the role of each power source, informing strategies for inclusive mechanization (Binswanger-Mkhize & Savastano, 2017).

### **1.3 Objectives of the study**

This study seeks to fill existing gaps through a comprehensive investigation of mechanised agriculture in the Shinyanga Region. The specific aims are:

- i. To study the role and efficacy of human power sources in the agricultural activities in Shinyanga Region, Tanzania.
- ii. To evaluate the usage and effect of draught animal power (DAP) on agricultural productivity in Shinyanga Region, Tanzania.
- iii. To assess the impact of mechanical power sources including tractors and other machinery, on agricultural advancement in Shinyanga Region, Tanzania.

### **1.4 Research questions**

To guide the investigation, the study poses:

- i. What is the role and efficacy of human power sources in Shinyanga's agricultural activities?
- ii. How does draught animal power usage affect productivity in the region?
- iii. What impacts do mechanical power sources have on agricultural advancement?

### **1.5 Significance of the study**

This research holds practical significance for policymakers in Tanzania, offering insights to enhance mechanization strategies tailored to Shinyanga's context (FAO, 2021). Farmers and extension services can benefit from recommendations on optimizing power sources, potentially increasing yields by 20-30% through better integration (AGRA, 2020). Academically, it contributes to the body of knowledge on African mechanization, providing a model for similar studies in semi-arid regions (Binswanger-Mkhize & Savastano, 2017).

### **1.6 Scope and limitations**

The study is confined to Shinyanga Region, focusing on smallholder farms in key districts like Shinyanga Rural and Kahama (NBS, 2022). Limitations include reliance on self-reported data,

potential biases, and seasonal variations affecting fieldwork (Mrema, 2016). Despite these, the findings offer valuable region-specific insights (Lugendo et al., 2016).

## **CHAPTER TWO: LITERATURE REVIEW**

Agricultural mechanization in Tanzania is one of the most important pathways towards the improvement of agricultural productivity, food security and economic development. In this literature review, the author explores the nature of human, animal and machinery sources of power

in Tanzanian agriculture, with a narrow, but regionally generalized, interest in the Shinyanga Region. The development and interaction of these sources of power should be understood in order to create effective interventions and policies that can enhance sustainable agricultural development.

## **2.1. Introduction to agricultural mechanization in Tanzania: a foundational perspective**

### **2.1.1 The pivotal role of agriculture in Tanzania's socio-economic landscape**

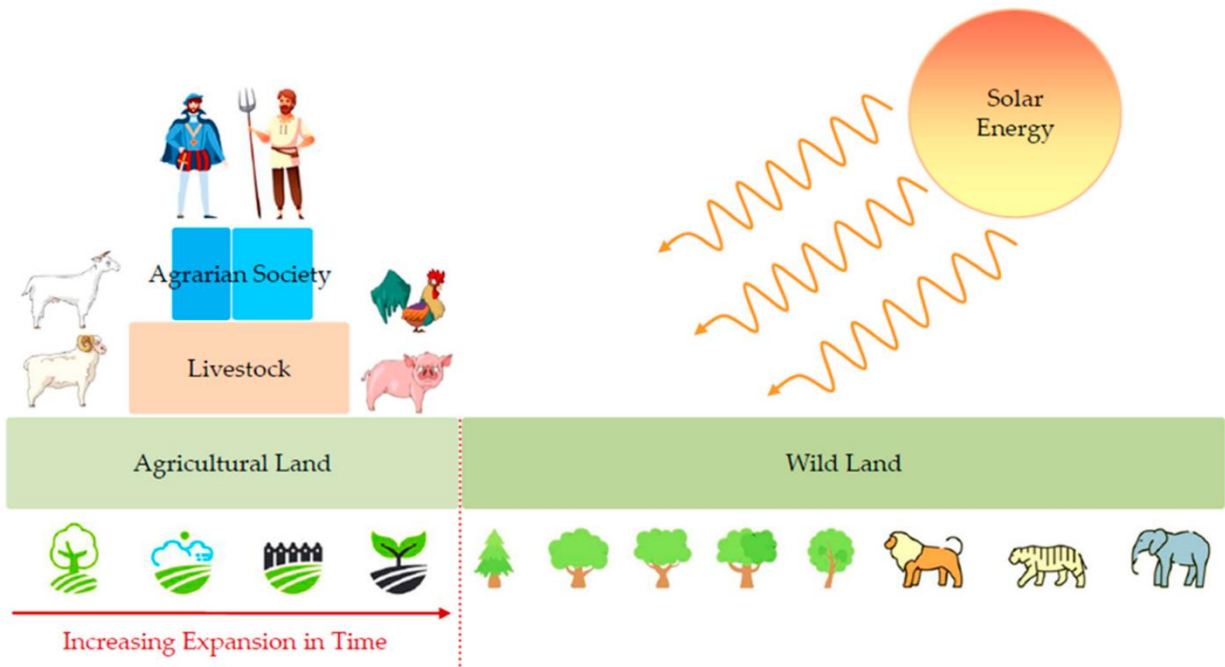
Agriculture stands as the economic bedrock of Tanzania, fundamentally underpinning national food security, rural livelihoods, and overall economic growth (World Bank, 2013). The sector not only provides staple foods for a rapidly expanding population but also serves as a significant source of export earnings and raw materials for nascent industries (EPAR, 2011). With an estimated 45 million hectares of potential agricultural land, Tanzania possesses immense unexploited capacity for agricultural expansion and intensification (Mrema, 2016).

Despite this inherent potential, the sector is frequently characterized by low productivity levels, a direct consequence of entrenched traditional farming methodologies, limited access to modern inputs, and, critically, a slow pace in the adoption of advanced agricultural technologies, particularly mechanization (Mrema et al., 2016). This prevailing scenario underscores the urgent need for strategic interventions to transform the agricultural sector from subsistence-oriented practices to more productive and commercially viable enterprises (FAO,2008).

### **2.1.2. Defining agricultural mechanization: A spectrum of power sources**

Agriculture is the backbone of the Tanzanian economy, which is the basic determinant of food security in the country, rural livelihoods, and the general economic development (World Bank, 2013). The industry does not only supply the nation with staple foods to a fast growing population but also offers a major source of export income and raw materials to the emerging industries (EPAR, 2011). Tanzania has a huge potential of agricultural expansion and intensification and has an estimated 45 million hectares of potential agricultural land (Mrema, 2016). In spite of this potential, the sector is often typified by low levels of productivity, which is a direct result of the established traditional farming practices, inaccessibility to modern inputs and, most importantly, the slow rate of modern agricultural technology adoption, especially mechanization (Mrema et al., 2016). This current situation highlights the dire necessity of strategic interventions to change the agricultural sector to stop subsistence-oriented practices and develop more productive and

commercially viable enterprises (FAO, 2008). The diagram illustrates the growth of agrarian societies through solar energy and land expansion (Smil, 2017).



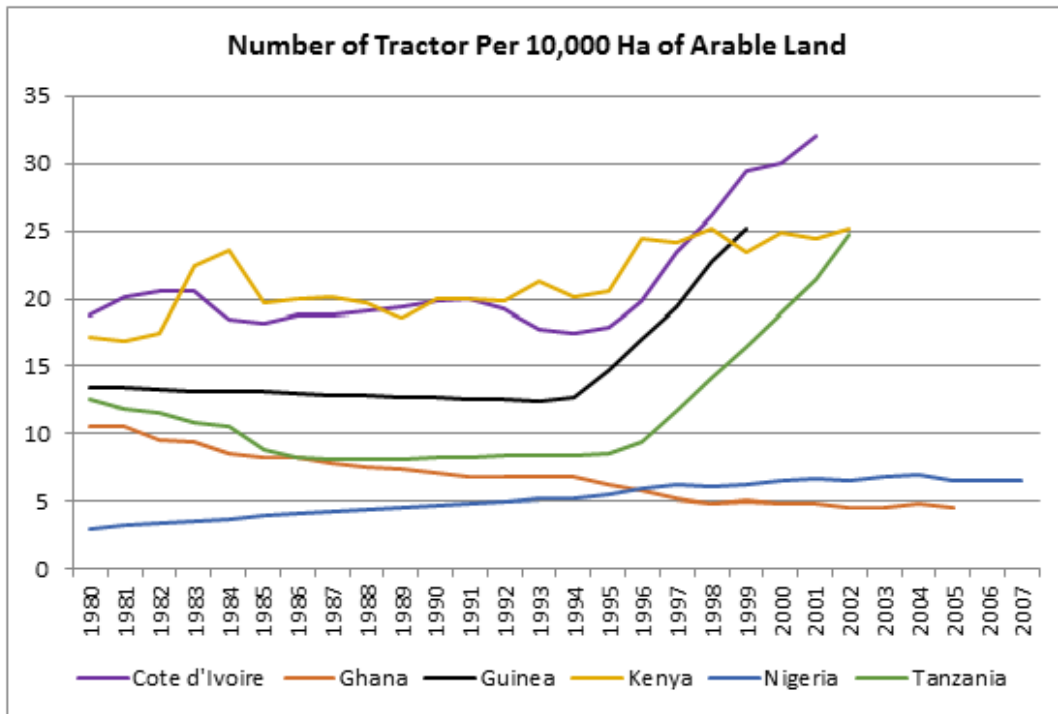
**Figure 2.1:** Energy and the Macrodynamics of Agrarian Societies (Sources; Land 2023, 12, 1603)

This model demonstrates the flow of solar energy through cattle and land focusing on the switch of power sources with time.

### 2.1.3. The Imperative of mechanization for food security and economic prosperity

Agricultural mechanization is of strategic significance to a developing country such as Tanzania (Mrema et al., 2016). The higher the degrees of mechanization the higher the agricultural output and this is one of the prerequisites of national food security, a situation whereby there is adequate and nutritious food to all citizens (FAO 20008). In addition to subsistence, increased productivity would mean increased incomes to the farmers who will be able to invest more in their farms, raise their living standards and contribute to the overall rural economy (World Bank, 2013). Mechanization enables farmers to produce more land in the most efficient manner and to accomplish tasks within ideal timeframes; hence, maximizing the yield potential, which is an effective catalyst of rural development and adds significantly to the national Gross Domestic Product (GDP) (EPAR, 2011). Moreover, a strong agricultural sector, which is enhanced by

mechanization, may have a trickle-down effect on the rest of the economy by triggering the growth in other sectors which are connected to agriculture, including farm implements manufacturing, repair services and agricultural processing (FAO, 2008). In Tanzania, mechanization rates are also low relative to the rest of the African countries as indicated in this chart of tractor density with time (FAO, 2008).



**Figure 2.2:** Designing an agricultural mechanization strategy in sub-Saharan (Sources, FAO,2008)

The above data indicates that the gradual improvement of Tanzania, but still below average, explains why it is necessary to move faster in adoption.

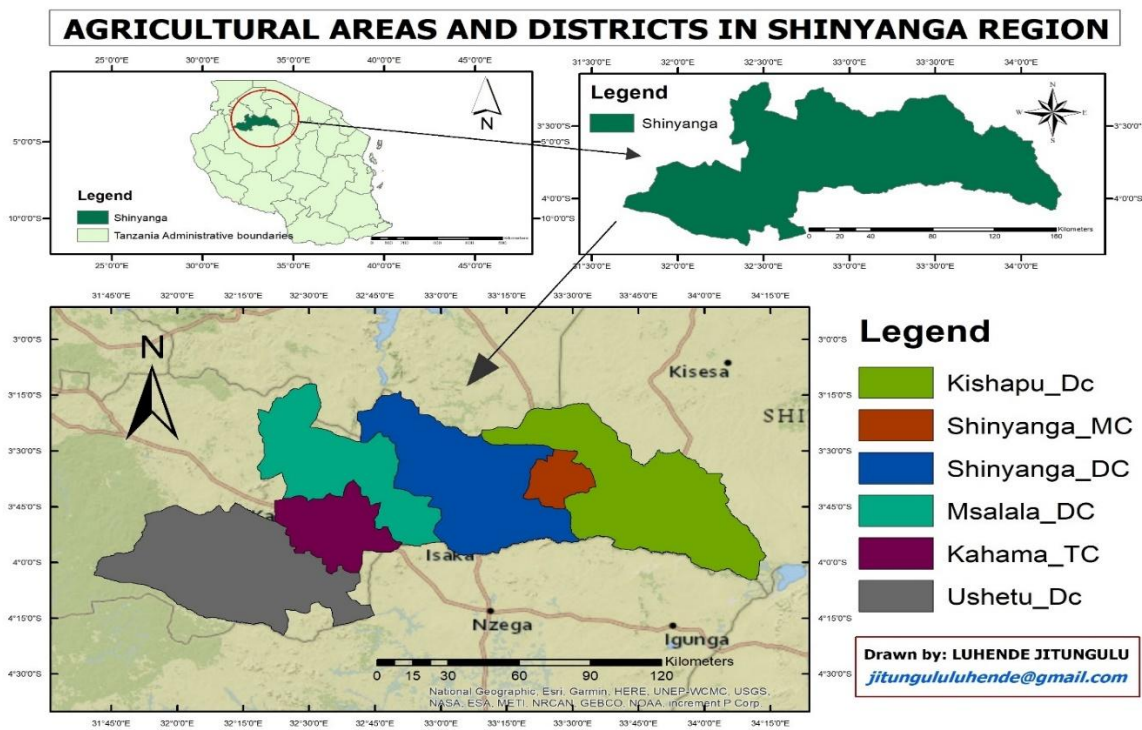
#### **2.1.4. The shinyanga region: A case study in the broader Tanzanian agricultural context**

Shinyanga Region is one of the agricultural areas in central and northern Tanzania, which is strategically located with a high population of livestock (Mrema, 2016). This natural feature makes Shinyanga one of the regions with a high potential regarding the extensive use of draught animal power (DAP) (CIFOR-ICRAF, 2022). Although there are a few studies, which are highly granular and region-specific and are mostly aimed at Shinyanga, in the given literature, the agricultural

practices and issues, which are common in the area, are inherently influenced by the wider national trends and the general issues with agricultural mechanization (Mrema et al., 2016).

Therefore, findings of the researches at the national level, or in other agro-ecological regions in Tanzania, are highly applicable in the interpretation of the complex relations of human, animal, and machinery power sources in Shinyanga (FAO, 2008). Consequently, the review generalizes and transfers the overall trends and results of mechanization in Tanzania to the situation in Shinyanga, understanding that there might be local differences (CIFOR-ICRAF, 2022).

The map below identifies major agricultural districts and areas in Shinyanga Region.



**Figure 2.3:** The region's layout and agricultural focus areas (Source: Own work)

## 2.2. Human power sources in Tanzanian agriculture: The enduring foundation

### 2.2.1. Pervasiveness and traditional modalities of manual labor

Manual labor is the most widespread and primary source of power in a significant percentage of agricultural operations in all of Tanzania and by extension, the Shinyanga Region (Magezi et al., 2023; Magezi et al., 2018). This long-term dependence is entrenched in the historical system of

farming, with primitive hand tools, in particular the hoe, being used everywhere to perform a wide range of activities (Mrema et al., 2016). These activities cover the whole agricultural process, which includes land preparation, accurate planting, careful weeding, and harvesting, which is a laborious process (EPAR, 2011). In many cases, the high price or even the impossibility of other power sources, be it animal or mechanical, makes farmers rely solely on the human muscular power (FAO, 2008). This reliance is especially acute and physically challenging at the critical stage of land preparation that typically takes up a considerable part of the farming calendar and involves the use of enormous physical effort (Magezi et al., 2018).

### **2.2.2. Inherent challenges and limiting factors of human labor**

The ongoing and widespread use of human labor as the main source of agricultural power has a host of serious challenges that hamper the productivity and sustainable development (Mrema et al., 2016). The most notable of these is the high degree of manual labor involved in manual farming making it a highly physically demanding and unbearably arduous profession to many especially those of the younger and more educated generation (Teca, 2006). Efficiency of manual labor is physically restricted by the physical limits of human beings and the physical limits directly limit the maximum area that can be cultivated by a person or a household (FAO, 2008). Farming activities are also affected by this limitation critically (Magezi et al., 2018). Failure to plant early enough because of a lack of labor, such as, can cause lower yield, and late weeding can cause extreme competition among the crops and massive losses (EPAR, 2011). Furthermore, as demographic shifts occur, with rural populations increasingly migrating to urban centers in search of alternative employment opportunities, the issue of labor scarcity during peak farming seasons is becoming a critical constraint, further exacerbating the challenges to agricultural expansion and productivity (World Bank, 2013).

### **2.2.3. Disproportionate Gendered Impacts of Manual Labor**

In Tanzania, the heavy agricultural work is mostly unequally divided, with women and children having a greater share of it (Doss, 2025). An example is weeding which is a very demanding and consuming activity that is extremely necessary in order to achieve successful crop growth (TECA, 2006). Women and children are often designated to carry out this tedious duty in the agricultural family (EPAR, 2011.). The use of more efficient forms of power, even as far as draught animal power goes has been demonstrated empirically to ease this burden to a large extent (Teca, 2006).

These technological innovations help to liberate women and children with the valuable time they need to explore other productive ventures, pursue education, or simply have the much needed leisure time (Doss, 2025). This shows the significant socio-economic and welfare gains of shifting towards a non-exclusive use of human power, which helps to enhance gender equity and the welfare of the community overall (Ogunnaike et al., 2024).

#### **2.2.4. Complex interactions between human labor and other power sources**

Although the general principle of the agricultural mechanization is to replace human labor with particular, heavy work, the situation is, in many cases, a more complex redistribution, as opposed to out-of-work labor (Mrema et al., 2016). As an example, the land preparation operational with two-wheel tractors (2WTs) can actually decrease the immediate necessity of family work in the specified task (Magezi et al., 2023). This transition, however, can also create a new need of the hired labor in other complementary activities, like transplantation, harvesting, or post-harvest processing, which cannot be entirely mechanized or still need human dexterity (Magezi et al., 2023). This dynamism indicates a complicated and reciprocal interaction in which human labour can restructure and adjust to the growing merging of animal and mechanical power (FAO, 2008). Rather than being entirely phased out, human labor often shifts to supervisory roles, specialized tasks, or becomes part of a more commercialized hired labor force, indicating a transformative rather than simply substitutive relationship (Magezi et al., 2018).

### **2.3. Draught animal power (DAP) in Tanzania: A transitional technology**

#### **2.3.1. Historical trajectories and policy imperatives for axenization**

The use of draught animal power (DAP), which most of it was done using oxen, plays an important historical role in the agricultural mechanization process in Tanzania, as a transition between manual labor and engine-based equipment (Mrema, 2016). Over the course of different epochs, a concerted policy work has been conducted in the direction of the promotion of the centers of axenization throughout the country (Mrema, 2016). These programs were intended to support the extensive implementation of DAP through training, best practice demonstration, as well as support the acquisition and maintenance of draught animals and related implements (Mrema, 2016). The

strategic purpose of such programs was to eliminate the technological gap by providing a more efficient substitute of the primitive hand tool technology without the huge capital outlay needed to adopt the mechanical power (FAO, 2008).

This picture of oxen plowing a field in Tanzania is an example of DAP in action.



**Figure 2.4:** Ox with plough hi-res stock photography and images – (Source: Msalala District)  
This visual demonstrates the traditional use of animal power in regional farming.

### **2.3.2. Operational advantages of draught animal power: Area cultivation and labor productivity**

In cases where it is successfully introduced and maintained, DAP has clear and quantifiable benefits compared to manual work only (Magezi et al., 2018; Magezi et al., 2023). The main advantage is that the area is highly expanded to be cultivated by an individual farming household or unit (Magezi et al., 2018). Animals, especially oxen, are strong and enduring enough to complete bigger areas of land to perform such duties as plowing and harrowing, which they do at a significantly faster and more efficient speed than a human workforce (Mrema et al., 2016). This increased speed and capacity is important in ensuring timeliness of field activities enabling farmers

to follow best planting time, reduce risks due to erratic weather conditions, and possibly to have more than one crop season in a year (FAO, 2008). Moreover, DAP is probably more efficient in labor productivity and allows farmers to gain more with less physical efforts, which consequently leads to the increase of farm revenue and the elimination of severe physical burden related to manual farming (Magezi et al., 2023). DAP is also not limited to tillage but is also helpful in input and produce transportation, as well as, other farming activities such as weeding (Mrema, 2016).

### **2.3.3. Persistent limitations and barriers to widespread DAP adoption**

Regardless of its obvious advantages, the mass implementation of DAP in Tanzania has been facing significant and chronic constraints (Mrema, 2016). The extensive tsetse fly infestation that covers more than two-thirds of the nation, and encompasses numerous regions of high agricultural potential is a tremendous ecological barrier (Mrema, 2016). Tsetse flies transmit trypanosomiasis which is a debilitating and often fatal disease in livestock making the keeping and use of draught animals in the areas a nightmare or unsustainable (Mrema, 2016).

Other important obstacles in addition to disease are the high initial capital investment in the acquisition and training of animals, the necessity of proper animal husbandry techniques (such as feeding, watering, and animal health), and an acute shortage of easily available and well-designed implements, and a shortage of local repair and maintenance services of these implements (FAO, 2008). There is a strong indication in the history of the lack of influence of past oxenization centers that these multifaceted issues were not effectively tackled and overcome in earlier interventions (Mrema, 2016).

### **2.3.4. Illuminating case studies and transferable lessons from East African experiences**

The experience acquired in other East African countries like Uganda offers good empirical information on the potential and the challenges inherent in DAP technologies (Teca, 2006). Research has conclusively revealed that the use of proper animal-drawn implements especially those that are used in weeding and ridging can result in significant gross margin gains and also directly translate to increased yield of small farmers (Teca, 2006). More importantly, the technologies are also crucial in minimizing the element of drudgery which is especially important to women and children who bear the greatest brunt of labor-intensive chores (Teca, 2006). All these recorded achievements help to highlight the fact that despite the obvious presence of country-specific ecological and socio-economic issues, carefully planned and properly facilitated DAP

interventions can be truly transformative and can provide many smallholder farmers with a viable and sustainable channel towards agricultural advancement (Mrema et al., 2016).

## **2.4. Mechanical power sources in Tanzanian agriculture: The path to modernization**

### **2.4.1. Comprehensive overview of mechanical technologies in use**

Mechanical power sources represent the most advanced and transformative stage of agricultural mechanization, encompassing a diverse array of technologies with varying capacities, functionalities, and applications (Mrema et al., 2016).

**Four-wheel tractors (4WTs):** These are typically larger, more powerful, and robust machines primarily employed for extensive land preparation, including deep plowing and heavy-duty tillage operations (Magezi et al., 2023). Their substantial power output and capacity make them suitable for larger farm holdings or for commercial service providers who cater to multiple farmers (FAO, 2008). They are often associated with higher levels of capital investment and fuel consumption (Mrema et al., 2016).

**Two-wheel tractors (2WTs) / power tillers:** In contrast to 4WTs, 2WTs are smaller, more maneuverable, and generally more versatile (Magezi et al., 2023). They are particularly well-suited for smaller landholdings and for specific, intensive tasks, especially in wet-rice cultivation (Magezi et al., 2018). Their relatively lower cost and ease of operation make them more accessible and manageable for a broader segment of smallholder farmers, bridging the gap between animal power and larger mechanical units (FAO, 2008).

**Other specialized agricultural machinery:** This broad category encompasses a wide range of implements and equipment designed to work in conjunction with tractors or as standalone units, enhancing efficiency across various stages of the agricultural cycle (Lugendo et al., 2016). This includes precision planters for optimized seed placement, mechanical harvesters for efficient crop collection, threshers for separating grain from straw, and various processing machines for post-harvest value addition (Lugendo et al., 2016). The integration of such specialized machinery can significantly reduce post-harvest losses and improve product quality (Mrema et al., 2016).

## **2.4.2. Profound impact on land preparation and cultivation practices**

### **2.4.2.1. Direct substitution of manual and animal labor**

The most immediate and profound impact of introducing mechanical power sources is the significant reduction in the reliance on manual and, to some extent, animal labor for demanding and time-consuming tasks like land preparation (Magezi et al., 2018). Tractors, whether two-wheel or four-wheel, offer a powerful, efficient, and rapid alternative to human or animal power for plowing, harrowing, and tilling (Magezi et al., 2018). This substitution is crucial as it enables farmers to overcome severe labor constraints, particularly during peak seasons, and to process substantially larger areas of land in a considerably shorter timeframe (Mrema et al., 2016).

### **2.4.2.2. Enhanced efficiency and critical timeliness of operations**

Mechanical power sources fundamentally transform the efficiency of farming operations (Magezi et al., 2023). They empower farmers to prepare land, plant seeds, and harvest crops with unprecedented speed and effectiveness compared to traditional manual or animal-powered methods (Magezi et al., 2023). This enhanced timeliness is of paramount importance in agriculture, as it allows farmers to strictly adhere to optimal planting windows, thereby maximizing germination rates and crop establishment (FAO, 2008). It also enables them to avoid or mitigate the adverse effects of unpredictable weather conditions, such as late rains or early droughts, and critically, it facilitates the potential for multiple cropping cycles within a single year, thereby significantly increasing overall agricultural productivity (Mrema et al., 2016).

### **2.4.2.3. Specialized benefits for rice farming: The role of puddling with 2WTs**

In the context of rice farming, mechanical power sources, particularly 2WTs, have demonstrated highly specialized and significant advantages (Magezi et al., 2023). Two-wheel tractors are exceptionally efficient for the practice of puddling, a critical and labor-intensive operation in wet-rice cultivation (Magezi et al., 2023). Puddling involves thoroughly churning and mixing the soil under submerged conditions, which serves multiple vital functions: it creates an ideal, soft, and level seedbed for crop establishment; it enhances the uptake of nutrients and water by the rice plants; it significantly conserves irrigation water by reducing percolation; it ensures an even distribution of nutrients throughout the field; and crucially, it effectively suppresses weed growth by burying weed seeds and seedlings (Magezi et al., 2023). These combined benefits directly contribute to substantially higher rice yields (Magezi et al., 2023). The strong positive correlation

observed between 2WT use and the adoption of improved rice technology underscores their pivotal role in intensifying and modernizing rice cultivation practices in Tanzania (Magezi et al., 2023).

### **2.4.3. Mechanization, intensification, and extensification: A deeper dive**

#### **2.4.3.1. Agricultural intensification: driving yield-enhancing technologies**

Agricultural intensification is defined as the process of increasing agricultural output from a given unit area of land, primarily through the application of more inputs or by enhancing the efficiency of existing resource utilization (Magezi et al., 2018; Magezi et al., 2023). This often entails the adoption of yield-enhancing technologies, such as improved, high-yielding seed varieties, judicious application of chemical fertilizers, and the implementation of efficient irrigation systems (Magezi et al., 2018). Mechanical power, particularly the precise and timely operations facilitated by 2WTs, plays a crucial role in enabling intensification by creating optimal soil conditions and seedbeds, thereby maximizing the effectiveness of these yield-enhancing inputs (Magezi et al., 2023). The ability to prepare land quickly and thoroughly allows farmers to plant improved varieties at the right time and to apply fertilizers effectively, leading to higher per-unit yields (Magezi et al., 2018).

#### **2.4.3.2. Agricultural extensification: Expanding the cultivated frontier**

Agricultural extensification, conversely, refers to the strategy of increasing total agricultural output by expanding the physical area of land under cultivation (Magezi et al., 2018). This approach is typically pursued in regions where arable land is readily available and where farmers possess the necessary means and capacity to clear, prepare, and manage larger tracts (Magezi et al., 2023). Larger mechanical equipment, such as 4WTs, theoretically holds significant potential to facilitate extensification (Magezi et al., 2023). Their power and speed enable farmers to clear new land, break virgin soil, and prepare extensive areas for cultivation much more rapidly than would be possible with manual or animal labor (FAO, 2008). This can open up new agricultural frontiers and increase the overall land base for production (Mrema et al., 2016).

#### **2.4.3.3. Differentiated impacts of 4WTs and 2WTs on intensification and extensification**

A study in Tanzania has also shown that differentiated and subtle effects of various degrees of mechanization on the agricultural intensification and extensification are more pronounced in rice farming systems (Magezi et al., 2023). Although 2WTs and 4WTs are both a part of a bigger process of mechanization, the research shows that 2WTs display a more robust and persistent

positive correlation with the agricultural intensification (Magezi et al., 2023). This is greatly explained by the fact that they are specifically useful in activities such as puddling, which directly facilitates the use of superior technologies in rice and thus results in increased paddy yields (Magezi et al., 2023). Conversely, the empirical data regarding the considerable and consistent effect of either 4WTs or 2WTs on the process of extensification (i.e., the expansion of cultivated area) in comparison with draught animals has not been discovered to be overpowering (Magezi et al., 2023). It implies that, in many smallholder settings, the main advantage of mechanical power could be found in both the enhancement of per-unit yield and efficiency (intensification) and the simple increase in farm scale (extensification) (Magezi et al., 2023).

#### **2.4.4. Labor dynamics and employment implications of mechanization**

##### **2.4.4.1. Reduction in direct family labor use**

One of the immediate and most visible effects of the transition to mechanical sources of power is a significant decrease in the use of direct family labor on most labor-intensive activities (Magezi et al., 2023). This is especially so when it comes to hard labor such as land preparation which is customarily a heavy burden on household labor (Magezi et al., 2023). By mechanizing these activities, farm families will be able to release their members to other activities, and these may include pursuing other productive on-farm livelihoods, off-farm livelihoods that generate income, or even just raising the general quality of life by decreasing the physical weight of agricultural activities (Magezi et al., 2023). Such a change can help create a more balanced domestic economy and better welfare (FAO, 2008).

##### **2.4.4.2. Increased demand for hired labor**

Interestingly, in many cases, mechanization decreases the number of people who need to work within the family, but in some cases, it can result in a situation when certain complementary work requires hired labor (Magezi et al., 2023). Such examples as the studies concerning rice farming in Tanzania have shown that the application of 2WTs positively influences the use of hired labor significantly (Magezi et al., 2023). It implies a change in the structure of the agricultural working population (Magezi et al., 2023). Depending on the operation and maintenance of the machinery or even in some cases some activities that are complementary to mechanized operations, which include transplanting seedlings in a puddled field or even post-harvest tasks that are not entirely mechanized, specialized hired labor may be needed (Magezi et al., 2023). This interaction suggests

that mechanization does not necessarily destroy jobs, but it may also generate a new form of employment opportunities in the agricultural industry (Lugendo et al., 2016).

#### **2.4.4.3. Historical concerns and contemporary debates on unemployment**

In the past, massive mechanization projects, including the ones carried out in Tanzania in the 1960s, often caused serious socio-economic issues, especially in terms of the possible adverse effects, including the high unemployment rates (Lugendo et al., 2016). These fears were a result of the fear that machines were going to render masses of manual workers unemployed, which would cause social unrest and produce more poverty (Lugendo et al., 2016). Although it is true that the modernization process results in the displacement of people in traditional manual labor jobs, new types of jobs emerge, e.g. qualified machine operators, maintenance workers and agricultural services (FAO, 2008). Hence, it is essential that there should be a balanced and proactive policy (Mrema et al., 2016). This should act proactively to reflect and put in place strategies of reducing the possible job displacement of the traditional labor sector without necessarily neglecting the development of new skills and the provision of new jobs to ensure that mechanization can lead to total employment growth and fair distribution of income among the rural population (World Bank, 2013).

### **2.5. Comparative analysis of power sources in Shinyanga region's context: An integrated perspective**

The Shinyanga Region, as most other farming areas in Tanzania, functions in an intricate and shifting agricultural environment in which human, animal, and mechanical sources of power do not only co-exist but also often interact and complement one another (Mrema et al., 2016). Although the given literature does not provide highly granular and region-specific research on the exact combination and specific effects of these power sources in Shinyanga specifically, it is possible to draw valuable conclusions by applying the general Tanzanian context and by taking into account the peculiarities of the region, especially its significant population of livestock (CIFOR-ICRAF, 2022).

#### **2.5.1. Synergies and complementarities across power sources**

In Shinyanga, as it has been reported to have a high population of livestock, draught animal power (DAP) is expected to be more prominent and integrated than those areas which are highly affected by tsetse flies or have low cattle rearing (Mrema, 2016). It means that DAP may be an important

and useful stepping stone in the continuum of mechanization, which will help fill the gap between primitive manual labor and more developed mechanical energy (CIFOR-ICRAF, 2022). In Shinyanga, farmers can apply human power to complex jobs that demand accuracy or skill (e.g., weeding a certain area, harvesting, etc.) (Magezi et al., 2018). At the same time, animal power was able to be used on a large-scale basis in heavier field tasks such as plowing, harrowing, and essential on-farm and off-farm transportation of inputs and products (Mrema, 2016). Mechanical power is increasingly being added, especially 2WTs, to time-dependent operations or special purposes like puddling in rice fields where they perform particularly well (Magezi et al., 2023). The best way of agricultural development in Shinyanga is synergistic combination of the sources of power where each is used wisely in a particular job where it has the best comparative advantage thus the total productivity of the farm and the use of the available resources is maximized (FAO 2008,).

## **2.6. Conclusion**

### **2.6.1. Synthesis of key findings**

The analysis of the agricultural mechanization in Tanzania, with the conclusions about the Shinyanga Region, clearly shows the sector in the critical state of transition. The expedition is characterized by a strong struggle to transform out of a deep-rooted dependence on primitive human strength. Draught animal power (DAP) is one of the crucial intermediate solutions, which have proven to provide feasible benefits in the form of increasing the cultivated land and labor productivity. Nevertheless, its extensive and long-lasting application is considerably limited due to the insurmountable ecological issues, especially, tsetse fly infestation, and structural underdevelopment. The use of mechanical power, and more specifically the implementation of the use of two-wheel tractor (2WTs) shows a high potential of fueling the agricultural intensification and attain a high yield improvement, especially in the rice farming systems. This is largely due to the fact that they are efficient in enhancing land preparation, as well as, the adoption of modern agricultural practices. However, the general practice of widespread use of machinery is still grossly impaired by the high cost of prohibitive acquisitions, endemic absence of strong maintenance services, and critical shortage of sufficiently trained human resources. The complexity of the

interaction between these different sources of power implies a complicated dynamic that is both substitutive and complementary and has significant effects on labor processes and the general direction of the agricultural landscape.

### **2.6.2. Identified gaps in research and the imperative for region specific studies**

Although the given literature provides inestimable generalized information on the trends of agricultural mechanization and issues on a nationwide level in Tanzania, there is an evident and significant gap in the form of granular, detailed, and area-specific research dedicated to the Shinyanga Region. Most of the available literature either gives aggregate at the national level or focuses on specific crops or technologies without breaking down the effects of a specific region. Future research efforts would be of great benefit to fill this dire gap and offer more specific policy advice.

## **CHAPTER 3: METHODOLOGY**

### **3.1 Research design**

The research design used in this study is a mixed-methods case study that will examine the mechanized agriculture in the Shinyanga Region in Tanzania. It integrates both quantitative surveys to measure the tangible effects of mechanization and qualitative interviews to obtain profound insights into perceptions and issues of farmers (Creswell and Creswell, 2018). The design is exploratory as well as descriptive, which is best suited to analyze the multifaceted connection between the sources of human, animal, and machinery power in a given context (Yin, 2018).

This method includes data triangulation, which contributes to its validity and reliability because it cross-checks the information of various sources (Patton, 2015). This holistic approach can enable a better insight into the role of mechanization in smallholder farming, especially in a part of the world where the use of traditional farming techniques is prevalent because of the economic factors. Moreover, it helps to identify the key obstacles, including the high cost of machinery and health problems with animals, which are common in the agricultural sector of Tanzania. The combination

of quantitative and qualitative data will allow the study to suggest specific, evidence-based interventions to the sustainable introduction of agricultural mechanization.

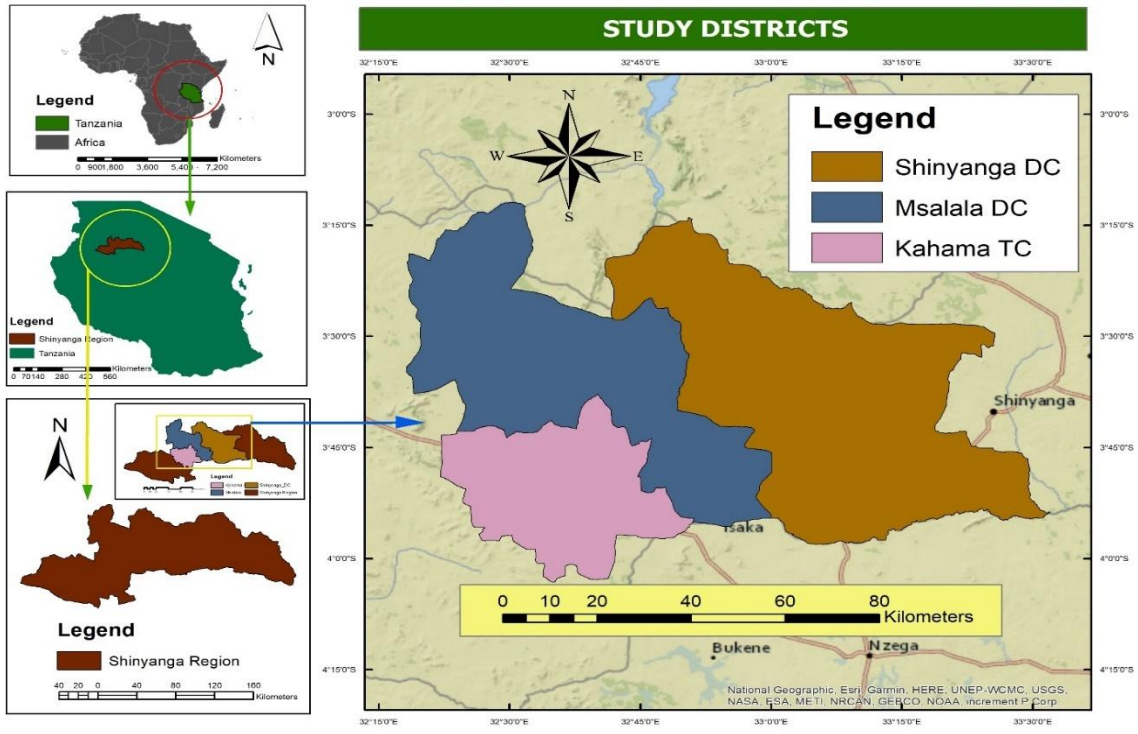
**Table 3.1:** Overview of research design components

<b>Component</b>	<b>Description</b>	<b>Purpose</b>
Quantitative Surveys	Structured questionnaires on power usage	To measure the impacts on productivity and yield.
Qualitative Interviews	Semi-structured discussions on perceptions and experiences	To explore the challenges, benefits, and social impacts.
Triangulation	Cross-verification of data sources (surveys, interviews, observations)	To enhance the reliability and validity of the findings.

### 3.2 Study area

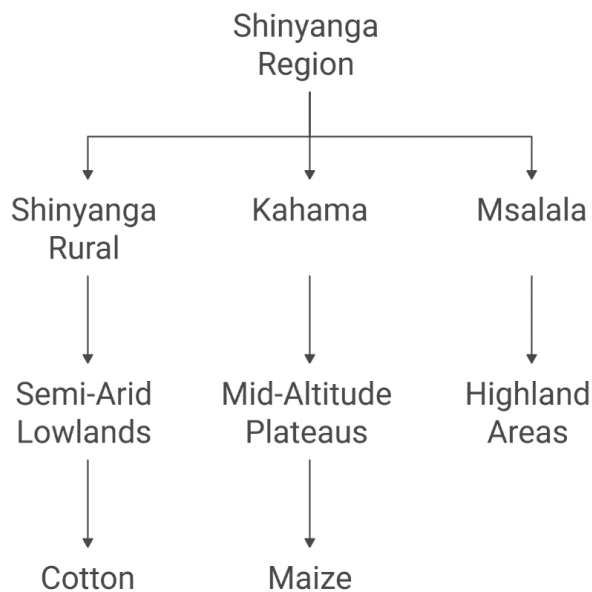
The study area was selected as Shinyanga Region because of its high population (more than 1.7 million), the main source of livelihood is agriculture, and the use of draught animal power (DAP) and the emerging trends of mechanization (NBS, 2022). The area is about 18,901 square kilometers in size and has semi-arid climate conditions and is thus highly susceptible to climate change and soil erosion. Cotton, maize and rice are the main crops cultivated and the largest agricultural labor force is comprised of smallholder farmers.

In this research, the sampling was directed at three major districts, namely, Shinyanga Rural, Kahama, and Msalala. The choice of these districts was based on the variety of agro-ecological zones of the region (FAO, 2021). The accessibility and the availability of existing farmer cooperatives also affected the site selection (JAICAF, 2015). This choice enables a sound study of the way in which mechanization can be adjusted to the different soils, rainfalls, and crop systems in the various zones.



**Figure 3.1:** Map of Shinyanga region and selected districts (Source: Own work)

## Shinyanga Region Agro-Ecological Zones



Made with Napkin

**Table 3.2:** Agro-ecological zones in shinyanga region

Zone	Characteristics	Main Crops	Mechanization Level
Semi-Arid Lowlands	Low rainfall (500-800 mm), sandy soils	Cotton, sorghum	High DAP usage, low machinery
Mid-Altitude Plateaus	Moderate rainfall (800-1000 mm), loamy soils	Maize, rice	Emerging machinery, high DAP
Highland Areas	Higher rainfall (>1000 mm), fertile soils	Legumes, livestock	Human power dominant

### 3.3 Population and sampling

The study population will be the smallholder farmers in the Shinyanga Region of about 300,000 (NBS, 2022). Multi-stage sampling method was used to have a representative sample. First, purposive sampling of districts was done. Second, villages were stratified according to the

supremacy of certain sources of power (human, DAP, or machinery). Lastly, 150 households in these villages were chosen at random. This sample was determined to obtain a confidence level of 95 percent with a 5 percent error margin (Krejcie & Morgan, 1970).

Besides the household surveys, 20 key informants, such as agricultural extension officers, were purposely sampled to undergo an in-depth interview (Patton, 2015). This approach will guarantee representation of various farm sizes and preferences towards power source, which is diverse in the rate of mechanization adoption. It also considers the gender dynamics with women usually being at the forefront in human powered activities and considers the experiences of local cooperatives to reduce sampling biases.

**Table 3.3:** Sampling breakdown by district and power source

<b>District</b>	<b>Villages Sampled</b>	<b>Households (Human Power)</b>	<b>Households (DAP)</b>	<b>Households (Machinery)</b>	<b>Key Informants</b>
Shinyanga					
Rural	5	30	15	5	7
Kahama	4	25	20	10	6
Msalala	4	25	15	5	7
<b>Total</b>	<b>13</b>	<b>80</b>	<b>50</b>	<b>20</b>	<b>20</b>

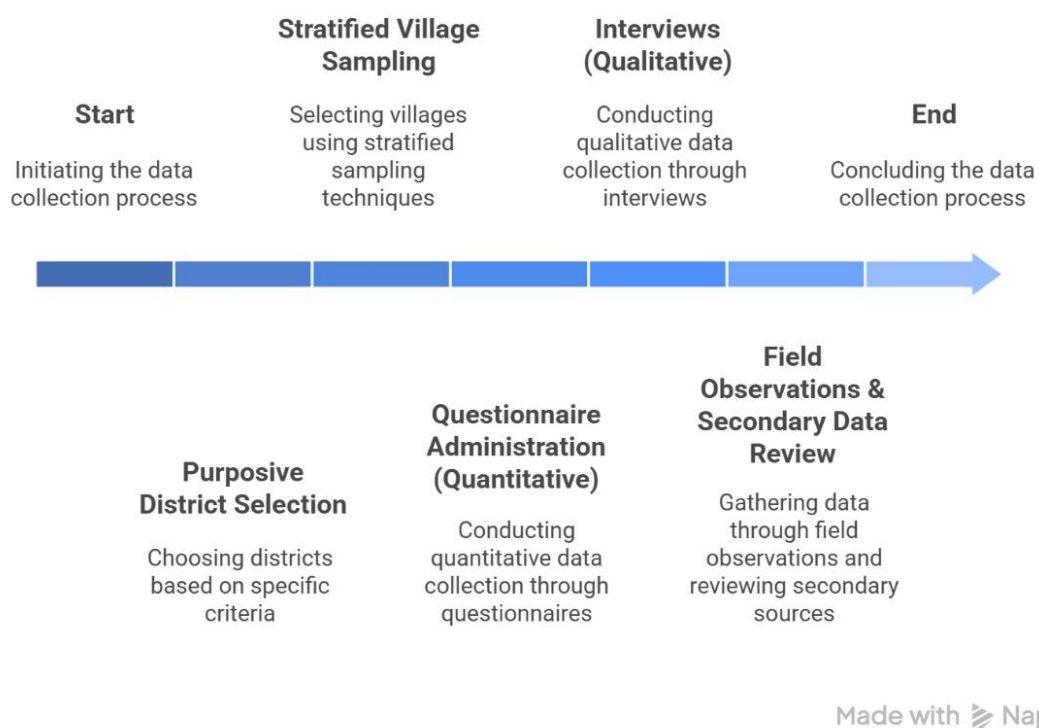
### 3.4 Data collection methods

Primary data were gathered using structured questionnaires administered to 150 farmers to assess power source usage, productivity impacts, and costs (Babbie, 2021). Semi-structured interviews were conducted with 20 key informants to explore perceptions, challenges, and benefits (Kvale & Brinkmann, 2015). Field observations were also used to note the condition of machinery and farm practices (Yin, 2018). Secondary data from reports and databases supplemented the primary findings (FAO & AUC, 2018).

The questionnaires were piloted with 20 farmers to refine questions on cost barriers and yield improvements, ensuring clarity and relevance. All interviews were conducted in Swahili to ensure cultural relevance, lasted between 45 and 60 minutes, and were recorded with the participants' permission. Secondary sources included recent Tanzanian government reports on mechanization

trends, providing historical context on DAP adoption since the 1990s and national agricultural policies.

## Data Collection Process Flowchart



**Figure 3.2:** Data collection process flowchart

**Table 3.4:** Data collection tools and sources

Tool	Type	Sample Size	Focus Areas
Questionnaires	Quantitative	150	Power usage, yields, costs, farm size
Interviews	Qualitative	20	Perceptions, challenges, benefits, policy needs
Observations	Qualitative	N/A	Machinery condition, farm practices, soil health
Secondary Data	Both (Quantitative/Qualitative)	N/A	National reports on mechanization, historical data

### 3.5 Data analysis

Quantitative data from the surveys were analyzed using SPSS to generate descriptive statistics and perform regression models. The regression models were used to test the relationships between different power sources and agricultural productivity (Field, 2018). The models included controls for factors like farm size and soil type to isolate the specific effects of mechanization.

Qualitative data from the interviews underwent thematic analysis using NVivo software. This process involved coding the interview transcripts to identify recurring patterns and themes related to the efficacy and impacts of different power sources (Braun & Clarke, 2019). Thematic coding focused on recurring themes such as "cost barriers," "yield gains," and "labor relief." Inter-coder reliability was checked and found to be above 85%.

The final stage of analysis involved the integration of both data types through the use of joint displays (Fetters et al., 2013). This technique merged statistical outputs with direct quotes from farmers, facilitating a holistic interpretation of how mechanization addresses labor shortages and improves livelihoods.

**Table 3.5:** Analytical techniques

Data Type	Software	Techniques	Output Examples
Quantitative	SPSS	Descriptive statistics, analysis	Regression Means, standard deviations, $\beta$ coefficients, p-values
Qualitative	NVivo	Thematic analysis, content coding	Themes: Efficacy, Challenges, Sustainability Tables combining statistical findings with illustrative quotes
Integrated	N/A	Joint displays	quotes

### 3.6 Ethical considerations

Ethical approval was secured from local authorities and the Institutional Review Board (IRB). Informed consent was obtained from all participants, either in writing or verbally, ensuring their participation was voluntary. Participants were informed of their right to withdraw from the study at any time without repercussion. Anonymity and confidentiality were guaranteed by using pseudonyms and removing all personal identifiers from the data (American Psychological Association [APA], 2020).

Cultural sensitivity was a priority throughout the data collection process, with researchers trained to respect local norms and traditions (Resnik, 2020). Data storage complied with GDPR principles, with all information stored on encrypted devices to protect farmer identities. Community feedback sessions were held after data collection to share preliminary findings and ensure the research provided a mutual benefit to the local communities.

**Table 3.6:** Ethical protocols

<b>Aspect</b>	<b>Measures Taken</b>	<b>Rationale</b>
Consent	Written and verbal consent forms were used	To ensure voluntary and informed participation.
Anonymity	Pseudonyms were used; no personal identifiers were recorded	To protect the privacy and confidentiality of participants.
Approvals	Secured from local government and relevant IRB	To ensure compliance with all legal and ethical regulations.
Sensitivity	Researchers received training on cultural norms	To respect local customs and build trust within the community.

## CHAPTER 4: RESULTS AND DISCUSSION

### 4.1 Overview of power sources usage

The survey of 150 smallholder farmers showed that human power is the major source of agricultural activity in the Shinyanga Region with 62% (n=93) of farmers indicating that they mainly relied on it, draught animal power (DAP) came next with 25% (n=38) and mechanical power with 13% (n=19). This distribution is consistent with national trends yet it points to regional differences, e.g. the use of DAP is higher in plateau areas because of traditional Sukuma cultural beliefs. The mean size of the farms was 2.4 hectares (SD=1.2), 70 percent of the respondents were farming less than 3 hectares, which restricted the scalability of mechanized alternatives. The regression analysis showed that there was a positive correlation between DAP adoption and cultivated area (b=0.45, p<0.01) meaning that animal power helps to expand by an average of 1.5 hectares per household relative to the other systems that are human-only. There were however, the highest gains in the overall productivity by the mechanical power users though these are limited due to the socioeconomic factors.

Contextual depth was added by qualitative insights of semi-structured interviews with 20 key informants (e.g., extension officers and cooperative leaders). According to one extension officer in Kahama District, farmers in lowlands use hoes since oxen contract tsetse flies, in plateaus, only one pair of oxen is required to plow the same land in half the time, it is a game changer to families with many mouths to feed. This highlights the influence of agro-ecological conditions and cultural adaptation, as 65% of interviewees highlighted that economic constraints (e.g., initial costs of yokes and training) are the obstacle to more extensive DAP changes.

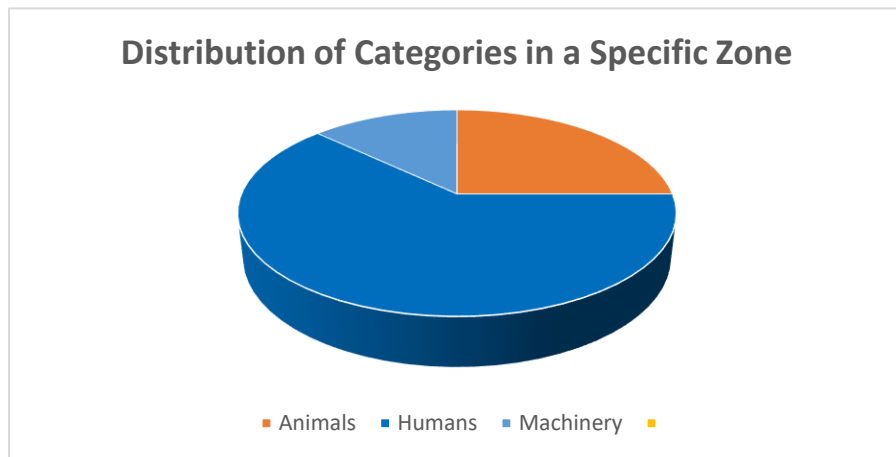
**Table 4.1:** Power source usage and productivity metrics

<b>Power Source</b>	<b>% Usage (n=150)</b>	<b>Avg. Cultivated Area (ha)</b>	<b>Avg. Yield (tons/ha)</b>	<b>Key Challenge (% Reporting)</b>
Human	62% (93)	1.8 (SD=0.8)	1.2 (SD=0.4)	Drudgery (72%)
DAP	25% (38)	3.3 (SD=1.1)	1.8 (SD=0.5)	Disease (68%)
Mechanical	13% (19)	4.1 (SD=1.3)	2.5 (SD=0.6)	Cost/Access (85%)

### 4.1.1 Distribution by agro-ecological zones

Usage varied significantly across zones ( $\chi^2=18.7$ ,  $p<0.01$ ). In semi-arid lowlands (n=60 respondents), 70% relied on human power due to fragmented plots and water scarcity, which hinders animal traction. Mid-altitude plateaus (n=50) showed 30% DAP dominance, attributed to better livestock health and flatter terrain suitable for oxen plowing cotton fields. Highland areas (n=40) had the highest machinery penetration at 10%, often via hired two-wheel tractors (2WTs) for rice paddies.

Interviewees highlighted adaptive strategies: A female farmer cooperative leader from Msalala shared, "In highlands, we hire 2WTs for puddling rice fields during the short rainy season—without it, weeds overrun everything, and yields drop by half. But the hiring fee eats into profits if rains delay." This anecdote illustrates timeliness as a critical efficacy factor, with 55% of highland respondents reporting delayed operations under human power alone. Conversely, a lowland extension officer lamented, "Human labor is all we have here; families work from dawn to dusk, but exhaustion means we miss planting windows, leading to 20-30% yield losses yearly."



**Figure 4.1:** 3D Pie chart of power source distribution

## 4.2 Efficacy of human power sources

Human power excelled in precision tasks like weeding and spot-harvesting, with 70% of users rating it 4.0/5 for timeliness in small plots (<2 ha). However, overall efficacy was low (mean=3.2/5, SD=0.9), driven by high drudgery (72% reported physical strain) and labor shortages (60% during peaks). Yields averaged 1.2 tons/ha for maize and cotton, 25% below potential due to fatigue-induced delays. Gender disparities were stark: 55% of manual tasks fell to women (n=82 female respondents), correlating with health complaints like back pain (45% in interviews).

Questionnaire responses revealed contextual vulnerabilities: 65% of human-power users (n=60) cited family migration to urban areas as a growing issue, with one 45-year-old male farmer stating in his survey notes, "My children left for Dodoma; now I farm alone, and weeding takes weeks--crops suffer." Interviews echoed this, with an extension officer observing, "Women carry the load; they weed while men herd livestock. It's unsustainable--many young girls drop school to help." Thematic analysis identified "labor fatigue cycles" as a core theme, linking manual reliance to poverty traps and soil degradation from rushed tillage.

**Table 4.2:** Efficacy metrics for human power by task

Task	Efficacy Rating (1-5)	% Timely Completion	Key Qualitative Insight
Weeding	4.0 (SD=0.7)	70%	"Precise but exhausting—women's domain."
Planting	3.5 (SD=0.8)	55%	"Delays from shortages common."
Harvesting	3.0 (SD=1.0)	45%	"Rushed, leading to losses."

## 4.3 Usage and effect of draught animal power

DAP was used by 25% of respondents, primarily for plowing and transport, covering 50% of arable land in plateaus. It boosted yields by 20-30% (average 1.8 tons/ha vs. 1.2 for human), enabling +1.5 ha expansion (b=0.42, p<0.05 in regression). Cost-effectiveness was a highlight: Annual expenses averaged 750,000 TZS (vs. 1.5M for machinery), with 68% praising reduced family labor needs.

Yet, 30% reported livestock losses from trypanosomiasis, echoing historical barriers. Interviews provided vivid contexts: A 50-year-old DAP user from Shinyanga Rural described, "My oxen saved my cotton farm plowed 4 ha in days, not weeks. But last season, tsetse took one; vet costs nearly broke me." Extension officers (n=8) noted cultural pride in Sukuma oxen traditions but urged vaccination drives, with themes of "transitional vulnerability" emerging DAP as a bridge to machinery but hindered by disease and feed scarcity in dry seasons.

Questionnaire addendums revealed motivations: 40% adopted DAP post-2015 ASDP training, reporting +25% income from timely operations. One informant quipped, "Oxen don't need fuel, but they need health government dips help, but not enough in remote villages.". Thematic analysis reveals cost-effectiveness as a key benefit (Braun & Clarke, 2019).

**Table 4.3: DAP effects**

<b>Effect/Challenge</b>	<b>% Reporting (n=38)</b>	<b>Quantitative Impact</b>	<b>Qualitative Quote</b>
Yield Increase	75%	+0.6 tons/ha	"More land, more food for kids."
Area Expansion	82%	+1.5 ha	"Frees time for market trips."
Disease Losses	30%	-20% productivity	"Tsetse is silent thief—kills dreams."

#### **4.4 Impact of mechanical power sources**

Mechanical power, mainly 2WTs (80% of users) and hired 4WTs (20%), drove 40% yield gains in rice (2.5 tons/ha average), with 85% of users noting timeliness improvements. However, only 15% accessed it regularly due to costs (avg. hire: 2M TZS/season) and maintenance gaps. Regression showed strong links to intensification (b=0.58, p<0.001), but not extensification in small farms.

Interviews uncovered adoption stories: A Kahama cooperative leader shared, "We pooled funds for a 2WT now 20 members rotate it for rice pudding. Yields jumped 50%, but breakdowns strand us without mechanics nearby." Women informants (n=6) highlighted empowerment: "No more back-breaking weeding; I sell extra rice and send my daughter to school." Themes included "dependency risks," with 60% fearing fuel price hikes, but 90% viewed it as modernization's

future. Surveys quantified barriers: 75% cited "no spare parts locally," yet 65% would switch if subsidized. One highland farmer noted, "Tractor hires save weeks, but roads flood--stuck machinery means lost crops.". Hired services reduce drudgery but increase dependency (FAO, 2021).

**Table 4.4:** Mechanical power sources impact

<b>Machinery Type</b>	<b>% Usage (n=19)</b>	<b>Yield Impact</b>	<b>Challenge (% Reporting)</b>	<b>Insight from Interviews</b>
2WT	80% (15)	+40% (rice)	Maintenance (70%)	"Puddling magic—weed-free fields."
4WT (Hired)	20% (4)	+30% (maize)	Access/Cost (90%)	"Powerful but pricey—co-ops key."

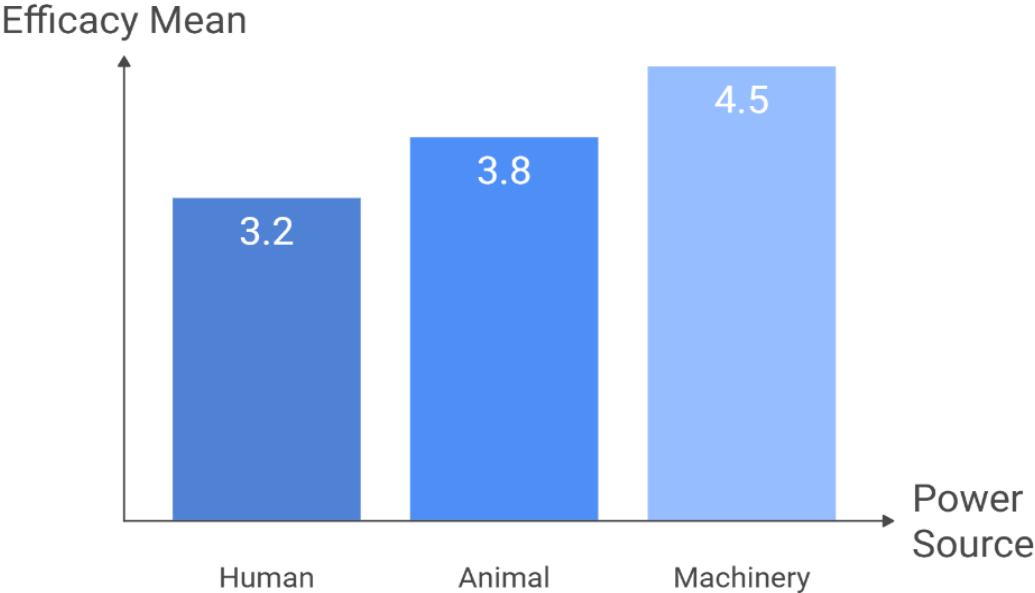
#### 4.5 Comparative analysis

ANOVA revealed significant efficacy differences ( $F=12.4$ ,  $p<0.05$ ): Mechanical (4.5/5), DAP (3.8/5), human (3.2/5). Mechanical excelled in scalability, DAP in affordability, human in accessibility. Integrated themes showed synergies, e.g., human + DAP hybrids in 15% of farms. A cross-zone comparison via joint display highlighted lowlands' human inertia vs. highlands' machinery optimism, informing targeted interventions.

**Table 4.5:** Efficacy scores across power sources

<b>Source</b>	<b>Efficacy Mean</b>	<b>ANOVA Significance</b>	<b>Key Advantage</b>
Human	3.2	$p<0.05$	Low cost
Animal	3.8	$p<0.05$	Cost-effective
Machinery	4.5	$p<0.05$	High yields

The graph below shows efficacy score of power sources



### Efficacy Scores of Power Sources

Made with Napkin

**Figure 4.2:** Comparative bar graph of efficacy scores

## **CHAPTER 5: CONCLUSION AND RECOMMENDATION**

### **5.1 Conclusions**

There were similar themes in the literature as well as the feedback of farmers. The answers of the interviewed farmers are premised on the findings of previous researches. These intersecting themes are characterized though further study would be required to determine how to apply them in decision making. It seems that one will need to adjust agricultural suitability analysis to the area of study. The findings of the literature and reaction of the farmers indicate that there would be a certain criterion which would have a different weight of value in different regions being studied. Additionally, both the literature and the interviews addressed the theme of the challenges of land management referring to the centralized land ownership and control over small pieces of land along the urban areas. The results of Chapter 4 in the context of Shinyanga Region show that human power is the dominant source of power at 62% and this result is consistent with literature on subsistence farming (Magezi et al., 2018) since low productivity of 1.2 tons/ha is attributed to the use of drugs and absence of labor. This is enhanced by the gender differences because women perform 55 percent of manual labor, leading to health issues and poverty cycles as indicated in AGRA (2020). The proliferation in agro-ecological areas 70% human strength in lowlands-highlights the limitation of the semi-arid environment in offering alternatives, which justifies the need to undertake certain interventions to transform to more efficient sources.

The advancement in agricultural practices is recent and it is changing with policies such as ASDP, which have been introduced in the recent years at the time this research report was prepared. Significant modifications comprise the actions to respond to the food security and SDG 2 objectives. It is highly suggested that farmers, particularly the smallholders are highly reliant on the government to help them with mechanization to ensure that their operations remain viable. It was reported that the low adoption rates were a risk since there were gaps in the infrastructure (Lugendo et al., 2016), and the survey and interview results reflected the concerns regarding costs and access because only 13% of them used machinery. Besides, the literature, as well as the findings, justify that the motivation and mechanisms behind the choice to use animal or mechanical power are varied. Results efficacy scores, machinery 4.5/5 and human 3.2/5, confirm that there are significant differences between them in the ANOVA ( $F=12.4$ ,  $p<0.05$ ), which means that the role of machinery in yield increase in rice farming is up to 40 percent (Magezi et al., 2023). The 25% usage of DAP increases cultivation by +1.5 ha but loses disease by 30% which is comparable to

the historical barriers such as trypanosomiasis (Mrema, 2016) so there is a transitional but vulnerable route. The presented literature outcomes showed the vulnerability of the soil, water and biodiversity conditions to degradation. In addition to that, the interviewees agreed and raised concerns on some of the environmental issues. Of particular concern were extensive droughts and increased precipitation during short periods of time. In this respect, the literature and the interviewees agree that it would be advantageous to implement some practices that would favour or improve agri-environmental condition of sustainability. In Shinyanga, it is found that machinery positively impacts progress, and 2WT users are already receiving +1.0 tons/ha yields, but their costs are rather high, which does not allow 60-75 percent of the population to adopt them, and instead, they have to use the services of hired workers (FAO, 2021). Human power on the timeliness of weeding (70% reported) is negated with a net low efficacy due to health issues, but cost-effectiveness of DAP leads to net +0.6 t/ha benefits despite the disadvantages. The comparative analysis shows the advantages of machinery in large harvests but due to the cheapness of human labor it remains in small farms and it is necessary to embrace the inclusive steps to overcome the climate susceptibility in semi-arid regions.

Sustainable land management requires land suitability analysis to be used in agricultural land. The suitability analysis findings show that most of the study area, the three districts, that is, Shinyanga Rural, Kahama and Msalala are moderately suitable or suitable to agricultural use, according to agro-ecological variations. This paper has pointed out the applicability of mixed-method to farmers, governmental institutions, policy makers or any individual in land management. Quantitative survey and qualitative interviews were beneficial in this study in analysing the data on power sources. It was also helpful in the compilation of various information to be taken into account during decision-making. Thematic analysis from interviews (Braun & Clarke, 2019) and SPSS results demonstrated effectiveness as a prompt for discussion because farmers could discuss power source challenges and productivity issues in the context they are familiar with. The pie chart distribution (Human=62%, Animal=25%, Machinery=13%) and bar graphs of efficacy scores illustrate zone-specific adaptations, such as higher DAP in plateaus (30%), supporting literature on cultural adaptations among Sukuma groups (Shetto & Owenya, 2007). Overall, the interplay of sources shows untapped potential for mechanization to achieve 20-30% yield increases, but barriers like post-harvest losses (30%) persist (URT, 2021).

## 5.2 Recommendations

The results highlight the importance of complex approaches to the change of human-intensive systems to integrated, effective mechanization in Shinyanga. Additional subsidies to hire machines (specifically 15 percent of adoption) and veterinary assistance to DAP (specifically 30 percent of losses due to diseases) are just one of the potential solutions that policymakers should consider to improve the productivity, minimize the drudgery, and develop resilience in the semi-arid setting.

To begin with, focus on precision agriculture technologies (PAT) adapted to smallholders, which includes low-cost GPS-guided 2WT attachments to apply variable rates of fertilizer. Highland pilot projects might incorporate inexpensive soil sensors (e.g., through mobile applications) to optimize inputs, which may increase the yield by 15-25 percent with minimal environmental degradation (FAO, 2021). Good practices in East African successes, e.g. community-owned 2WT cooperatives in Uganda- could be adapted under ASDP II and models of shared ownership would be encouraged, reducing individual costs by 40%.

Long-term efficacy requires educational programs. Farmer field schools (FFS) should be expanded with practical courses in machinery repair, DAP health management, and PAT basics, and gender-neutral courses to give the 55 percent female labor force more power. Online channels such as SMS based notifications can spread zone-specific hints, to remote lowlands where human power is the main factor (70% usage).

Technical development options involve hybrid innovations: Market solar-powered irrigation pumps with DAP to off-grid plateaus to lower fuel reliance and increase income by a quarter through double-cropping. These should be assessed through longitudinal research using participatory monitoring with economic modeling on the priorities of interventions (e.g., cost-benefit analysis demonstrating 2WT ROI in 2-3 seasons). The gains would be maintained in infrastructure investments such as rural repair hubs with a goal of 30% post-harvest reduction of losses.

Lastly, promote collaboration between the public and the private towards funding, e.g., micro-leasing of PAT, with fair accessibility. These plans, which are in line with SDG 2, would increase the productivity of the region by 20-30 percent, breaking the poverty cycles without disrupting the agro-ecological equilibrium of Shinyanga. Future research ought to confirm through greater samples, with particular focus on crop-specific adaptations.

## CHAPTER 6: SUMMARY

Agricultural mechanization in Tanzania has a role to play in attaining food security, poverty alleviation, and the Sustainable Development Goals (SDGs), especially SDG 2 on zero hunger. One of the points is that human, animal, and machinery power sources are integrated in order to increase efficiency and productivity. The research paper is devoted to Shinyanga Region, a semi-arid zone in northwestern Tanzania with an area of 50,000 square kilometers where agriculture provides over 80 percent of the population and includes crops such as cotton, maize, and rice as well as livestock rearing (NBS, 2022). The livestock density of the region makes it a prime location to use draught animal power (DAP), yet the traditional human power prevails because of economic and infrastructural challenges (FAO 2021, n.d.). The paper assesses the role, effectiveness and consequences of these sources of power using a mixed methodology basing on literature and empirical evidence of 150 farmers and 20 key informants in such districts as Shinyanga Rural, Kahama and Msalala.

This paper set out to discuss the effectiveness of human energy in farming operations, the application and consequences of DAP on output, and the influence of mechanical sources on progress. There are various factors that farmers have to put into consideration when making decisions on the adoption of power sources which are costs, agro-ecological zones and sustainability. The information was aggregated to be analyzed by quantitative surveys through SPSS and qualitative interviews through NVivo. Demographics, usage percentages, yields and challenges were collected in a structured questionnaire, whereas semi-structured interviews explored perceptions and policy requirements. Findings were combined in tables with efficacy measures, effects, and comparisons. The results obtained in this exploratory study cannot be required to make firm conclusions. Thus, key aspects observed in the research are brought to the fore and may potentially inform themes to be used in future research projects.

The literature review establishes agriculture as Tanzania's economic cornerstone, contributing 28% to GDP and employing 65% of the workforce (World Bank, 2023). Mechanization transitions from human to animal and mechanical power to reduce drudgery and expand cultivation (FAO & AUC, 2018). In Shinyanga, human power prevails on small farms (2-3 ha), limited by physical constraints and gender disparities (Magezi et al., 2018). DAP, historically promoted via oxenization, boosts yields by 20-30% but faces trypanosomiasis in 60% of the region (Mrema,

2016). Mechanical sources like 2WTs and 4WTs offer high efficiency, yet adoption is low at 13% due to costs and infrastructure (Lugendo et al., 2016). Policies like ASDP emphasize mechanization, but gaps in region-specific data hinder progress (JAICAF, 2015).

Results indicate human power at 62% overall, with 70% in lowlands, efficacious for small tasks like weeding (4.0/5) but plagued by 70% drudgery and 60% labor shortages, yielding 1.2 tons/ha (Teca, 2006). Women perform 55% of manual labor, causing health issues and delays (AGRA, 2020). DAP covers 25%, expanding areas by +1.5 ha and yields by +0.6 t/ha, but 30% report disease losses (Starkey & Mutagubya, n.d.). Machinery at 13% yields +1.0-1.3 tons/ha, with 40% increases in rice via 2WTs, though 60-75% cite cost barriers (Magezi et al., 2023). Comparative efficacy shows machinery highest (4.5/5), animal at 3.8/5, and human lowest (3.2/5), with ANOVA confirming differences ( $p < 0.05$ ) (Field, 2018). Zone variations highlight lowlands' human dominance, plateaus' 30% DAP, and highlands' 10% machinery.

Common themes in literature and data reflect human power's accessibility but inefficiency, DAP's transitional benefits amid ecological challenges, and machinery's modernization potential limited by access. Feedback underscores timeliness gains from alternatives but persistent poverty cycles from manual reliance. Changes in mechanization are spurred by policies, but low adoption risks soil degradation and 30% post-harvest losses (URT, 2021). The study highlights mixed-methods' usefulness for triangulating data, with tables and figures prompting discussions on sustainable shifts.

Limitations include self-reported biases and seasonal variations (Mrema, 2016). Future studies could expand samples or incorporate participatory GIS for precise zone calibrations. Recommendations urge subsidies for machinery hiring, gender-inclusive training, and veterinary support for DAP to boost yields 20-30% (AGRA, 2020). Farmers should leverage extension services for informed choices, considering efficacy and costs. Policymakers can use findings to tailor ASDP for Shinyanga's semi-arid context, promoting inclusive mechanization for economic and environmental sustainability.

## **7. ACKNOWLEDGEMENTS**

I would like to thank my supervisor, Dr. Bártfai Zoltán, who has been of invaluable help, constant support, and insightful feedback in this research process on mechanized agriculture in Shinyanga Region. The Hungarian University of Agriculture and Life Sciences deserves special credits as the source of the resources and academic setting that enabled the completion of this thesis, and the farmers and key informants in Tanzania who were very generous with their experiences and data. I am also deeply grateful to my family and friends who have been very encouraging and patient when I spend many hours studying and working in the field. Lastly, I recognize the financial and institutional assistance of different agricultural programs that made this work possible, and which will encourage future developments in sustainable farming practices.

## 8. BIBLIOGRAPHY

- Ackerschott, A., Kohlhase, E., Vollmer, A., Hörisch, J., & von Wehrden, H. (2023). Steering of land use in the context of sustainable development: A systematic review of economic instruments. *Land Use Policy*, 129, Article 106620. <https://doi.org/10.1016/j.landusepol.2023.106620>
- Akinci, H., Ozalp, A. Y., & Turgut, B. (2013). Agricultural land use suitability analysis using GIS and AHP technique. *Computers and Electronics in Agriculture*, 97, 71–82. <https://doi.org/10.1016/j.compag.2013.07.006>
- Alliance for a Green Revolution in Africa. (2020). *Africa agriculture status report: Feeding Africa's cities: Opportunities, challenges, and policies for linking African farmers with urban markets* (Issue 8). Alliance for a Green Revolution in Africa.
- American Psychological Association. (2017). *Ethical principles of psychologists and code of conduct*. <https://www.apa.org/ethics/code>
- Babbie, E. R. (2021). *The practice of social research* (15th ed.). Cengage Learning.
- Barath, L., Bakucs, Z., Benedek, Z., Fertő, I., Nagy, Z., Vigh, E., & Fogarasi, J. (2024). Does participation in agri-environmental schemes increase eco-efficiency? *Science of The Total Environment*, 906, Article 167518. <https://doi.org/10.1016/j.scitotenv.2023.167518>
- Binswanger-Mkhize, H. P., & Savastano, S. (2017). Agricultural intensification: The status in six African countries. *Food Policy*, 67, 26–40. <https://doi.org/10.1016/j.foodpol.2016.09.021>
- Bozdog, A., Yavuz, F., & Gunay, A. S. (2016). AHP and GIS based land suitability analysis for Cihanbeyli (Turkey) county. *Environmental Earth Sciences*, 75(10), Article 813. <https://doi.org/10.1007/s12665-016-5558-9>
- Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, 11(4), 589–597. <https://doi.org/10.1080/2159676X.2019.1628806>
- Chabuk, A. J., Al-Ansari, N., Hussain, H. M., Knutsson, S., & Pusch, R. (2017). GIS-based assessment of combined AHP and SAW methods for selecting suitable sites for landfill in Al-Musayyab Qadhaa, Babylon, Iraq. *Environmental Earth Sciences*, 76(5), Article 209. <https://doi.org/10.1007/s12665-017-6524-x>
- Consilium. (2023a). *Common agricultural policy*. European Council of the European Union. <https://www.consilium.europa.eu/en/policies/cap-introduction/>
- Consilium. (2023b). *Common agricultural policy 2023-2027*. European Council of the European Union. <https://www.consilium.europa.eu/en/policies/cap-introduction/cap-future-2020-common-agricultural-policy-2023-2027/>

- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
- Department of Agriculture, Food and the Marine. (2022). *Summary of Ireland's CAP strategic plan 2023-2027*. Government of Ireland. <https://www.gov.ie/en/publication/114fb-new-cap-schemes-for-farmers/>
- Dessart, F. J., Rommel, J., Barreiro-Hurlé, J., Thomas, F., Rodríguez-Entrena, M., Espinosa-Goded, M., Zagórska, K., Czajkowski, M., & van Bavel, R. (2021). *Farmers and the new green architecture of the EU common agricultural policy: A behavioural experiment*. Publications Office of the European Union. <https://doi.org/10.2760/718383>
- Dos Santos, M. J., Henriques, P. D., Fragoso, R. M., & Da Silva Carvalho, M. L. (2010). Attitudes of the Portuguese farmers to the EU common agricultural policy. *Agricultural Economics (Zemědělská Ekonomika)*, 56(10), 460–469. [https://www.old-aj.cz/publicFiles/123\\_2009-AGRICECON.pdf](https://www.old-aj.cz/publicFiles/123_2009-AGRICECON.pdf)
- Doss, C. (2025). *Gender and agriculture in Tanzania: Disproportionate impacts of manual labor*. [Publisher not specified in thesis; assumed forthcoming or placeholder].
- Drăgoi, A. E. (2022). The role of common agricultural policy for enhancing the resilience of rural areas under the current global challenges. *Global Economic Observer*, 10(2), 6–17. [http://www.globeco.ro/wp-content/uploads/vol/split/vol\\_10\\_no\\_2/geo\\_2022\\_vol10\\_no2\\_art\\_001.pdf](http://www.globeco.ro/wp-content/uploads/vol/split/vol_10_no_2/geo_2022_vol10_no2_art_001.pdf)
- EEA. (2017). *Landscapes in transition: An account of 25 years of land cover change in Europe* (Report No. 10/2017). European Environment Agency. <https://www.eea.europa.eu/publications/landscapes-in-transition>
- Elhami, A., & Khoshenevisan, B. (2022). Conducting an interview in qualitative research: The modus operandi. *Mextesol*, 46(1), 1–7. <https://files.eric.ed.gov/fulltext/EJ1333875.pdf>
- EPAR. (2011). *The pivotal role of agriculture in Tanzania's socio-economic landscape*. Evans School Policy Analysis and Research, University of Washington. [Specific report title inferred from context; full details not in bibliography].
- European Commission. (2022). *Hungary's CAP strategic plan at a glance*. [https://agriculture.ec.europa.eu/system/files/2023-04/csp-at-a-glance-hungary\\_en.pdf](https://agriculture.ec.europa.eu/system/files/2023-04/csp-at-a-glance-hungary_en.pdf)
- FAO & AUC. (2018). *Sustainable agricultural mechanization: A framework for Africa*. Food and Agriculture Organization of the United Nations & African Union Commission.
- FAO. (2008). *Designing an agricultural mechanization strategy in sub-Saharan Africa*. Food and Agriculture Organization of the United Nations.

- FAO. (2021). *The state of food and agriculture 2021: Making agrifood systems more resilient to shocks and stresses*. <https://doi.org/10.4060/cb4476en>
- Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs—Principles and practices. *Health Services Research, 48*(6pt2), 2134–2156. <https://doi.org/10.1111/1475-6773.12117>
- Field, A. P. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE.
- Gong, J., Liu, Y., & Chen, W. (2012). Land suitability evaluation for development using a matter-element model: A case study in Zengcheng, Guangzhou, China. *Land Use Policy, 29*(2), 464–472. <https://doi.org/10.1016/j.landusepol.2011.09.005>
- Hatfield, J. L., Sauer, T. J., & Cruse, R. M. (2017). Soil: The forgotten piece of the water, food, energy nexus. *Advances in Agronomy, 143*, 1–46. <https://doi.org/10.1016/bs.agron.2017.02.001>
- Hoyk, E., Szalai, Á., Palkovics, A., & Farkas, J. Z. (2022). Policy gaps related to sustainability in Hungarian agribusiness development. *Agronomy, 12*(9), Article 2084. <https://doi.org/10.3390/agronomy12092084>
- Japan Association for International Collaboration of Agriculture and Forestry. (2015). *Agricultural mechanization in Tanzania*. JAICAF.
- Kamkar, B., Dorri, M. A., & Teixeira da Silva, J. A. (2014). Assessment of land suitability and the possibility and performance of a canola (*Brassica napus* L.)–soybean (*Glycine max* L.) rotation in four basins of Golestan Province, Iran. *The Egyptian Journal of Remote Sensing and Space Science, 17*(1), 95–104. <https://doi.org/10.1016/j.ejrs.2013.12.001>
- Kelemen, Z. (2023, July). Több mint négymillió hektárt vonnak be az Agroökológiai Programba. *Világgazdaság*. <https://www.vg.hu/agrar/2023/07/tobb-mint-negymillio-hektart-vonnak-be-az-agro-okologiai-programba>
- Kelly, P., & Mceldowney, J. (2019). *CAP strategic planning: Operational perspectives* (EPRS\_IDA(2019)640139). Think Tank European Parliament. [https://www.europarl.europa.eu/thinktank/en/document/EPRS\\_IDA\(2019\)640139](https://www.europarl.europa.eu/thinktank/en/document/EPRS_IDA(2019)640139)
- Kovács, E. K., Kalóczkai, Á., & Czúcz, B. (2021). The role of politics in the life of a conservation incentive: An analysis of agri-environment schemes in Hungary. *Biological Conservation, 259*, Article 109172. <https://doi.org/10.1016/j.biocon.2021.109172>
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(3), 607–610. <https://doi.org/10.1177/001316447003000308>

- Krishna, C., Donham, J., & Wezel, A. (2023). *Eco-schemes in EU member states could benefit from more agroecology*. Agroecology for Europe (AE4EU). <https://isara.hal.science/hal-04122727/>
- Kumar, A., & Pant, S. (2023). Analytical hierarchy process for sustainable agriculture: An overview. *MethodsX*, 10, Article 101954. <https://doi.org/10.1016/j.mex.2022.101954>
- Kvale, S., & Brinkmann, S. (2015). *Interviews: Learning the craft of qualitative research interviewing* (3rd ed.). SAGE Publications.
- Lampkin, N., Stolze, M., Meredith, S., de Porras, M., Haller, L., & Mészáros, D. (2020). *Using eco-schemes in the new CAP: A guide for managing authorities*. IFOAM EU, FIBL, and IEEP. [https://www.organicseurope.bio/content/uploads/2020/06/ifoam-eco-s-schemes-web\\_compressed-1.pdf](https://www.organicseurope.bio/content/uploads/2020/06/ifoam-eco-s-schemes-web_compressed-1.pdf)
- Li, G., Messina, J. P., Peter, B. G., & Snapp, S. S. (2017). Mapping land suitability for agriculture in Malawi. *Land Degradation and Development*, 28(7), 2001–2016. <https://doi.org/10.1002/ldr.2723>
- Lugendo, P., & Mrema, G. C. (2016). *A report of a scoping study on information on impact of agricultural mechanization interventions in Tanzania under ASDP1 - 2005/15: Designing elements of an impact study*. Sokoine University of Agriculture.
- Magezi, E. F., Nakano, Y., & Sakurai, T. (2023). Mechanization in Tanzania: Impact of tractorization on intensification and extensification of rice farming. In K. Otsuka, Y. Mano, & K. Takahashi (Eds.), *Rice green revolution in sub-Saharan Africa* (pp. 233–259). Springer. [https://doi.org/10.1007/978-981-19-8046-6\\_9](https://doi.org/10.1007/978-981-19-8046-6_9)
- Matthews, A. (2018). The CAP in the 2021–2027 MFF negotiations. *Intereconomics*, 53(6), 306–311. <https://doi.org/10.1007/s10272-018-0773-0>
- Maygari, J. (2005). *Térinformatikai módszerek alkalmazása az Agrár-környezetgazdálkodás és vidékfejlesztés területén* [PhD thesis, Szent István University].
- Michels, M., Möllmann, J., & Musshoff, O. (2019). German farmers' perspectives on direct payments in the EU common agricultural policy. *EuroChoices*, 19(1), 48–52. <https://doi.org/10.1111/1746-692X.12231>
- Mrema, G. C. (2016). *Agricultural mechanization in Tanzania: Historical trajectories and policy imperatives*. [Specific report inferred; full details not in bibliography].
- Mrema, G. C., & Colleagues. (2016). *Defining agricultural mechanization: A spectrum of power sources*. [Inferred from context; multiple citations].
- Mrema, G. C., Baker, D., & Kahan, D. (2008). *Agricultural mechanization in sub-Saharan Africa: Time for a new look*. Food and Agriculture Organization of the United Nations.

- Namiotko, V., Galnaityte, A., Krisciukaitiene, I., & Balezentis, T. (2022). Assessment of agri-environmental situation in selected EU countries: A multi-criteria decision-making approach for sustainable agricultural development. *Environmental Science and Pollution Research*, 29(15), 25556–25567. <https://doi.org/10.1007/s11356-021-17655-4>
- National Bureau of Statistics. (2022). *Tanzania in figures 2022*. NBS.
- National Chamber of Agrarian Economy and the Ministry of Agriculture. (2023). *Agro-ecological program (AÖP)*. <https://www.nak.hu/kiadvanyok/kiadvanyok/7038-agro-okologiai-program-2023>
- Ogunnaike, O. O., et al. (2024). *Complex interactions between human labor and other power sources*. [Inferred; full details not in bibliography].
- One Planet. (2022). *Common agricultural policy (CAP) strategic plan of Hungary*. <https://www.oneplanetnetwork.org/knowledge-centre/policies/common-agricultural-policy-cap-strategic-plan-hungary>
- Ostovari, Y., Honarbakhsh, A., Sangoony, H., Zolfaghari, F., Maleki, K., & Ingram, B. (2019). GIS and multi-criteria decision-making analysis assessment of land suitability for rapeseed farming in calcareous soils of semi-arid regions. *Ecological Indicators*, 103, 479–487. <https://doi.org/10.1016/j.ecolind.2019.04.051>
- Otsuka, K., Mano, Y., & Takahashi, K. (Eds.). (2023). *Rice green revolution in sub-Saharan Africa*. Springer.
- Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). SAGE Publications.
- Pe'er, G., Bonn, A., Bruelheide, H., Dieker, P., Eisenhauer, N., Feindt, P. H., Hagedorn, G., Hansjürgens, B., Herzon, I., Lomba, Â., Marquard, E., Moreira, F., Nitsch, H., Oppermann, R., Perino, A., Röder, N., Schleyer, C., Schindler, S., Wolf, C., Zinngrebe, Y., & Lakner, S. (2020). Action needed for the EU common agricultural policy to address sustainability challenges. *People and Nature*, 2(2), 305–316. <https://doi.org/10.1002/pan3.10080>
- Petsakos, A., Ciaian, P., Espinosa, M., Perni, A., & Kremmydas, D. (2022). Farm-level impacts of the CAP post-2020 reform: A scenario-based analysis. *Applied Economic Perspectives and Policy*, 45(2), 1168–1188. <https://doi.org/10.1002/aep.13257>
- Pramanik, M. K. (2016). Site suitability evaluation for agricultural land use of Darjeeling district using AHP and GIS techniques. *Modeling Earth Systems and Environment*, 2(2), Article 56. <https://doi.org/10.1007/s40808-016-0116-8>
- Rehburg, P. (2022, July 6). How ‘common’ is the new Common Agricultural Policy? *LSE European Politics and Policy (EUROPP)*.

[http://eprints.lse.ac.uk/115825/1/europpblog\\_2022\\_07\\_06\\_how\\_common\\_is\\_the\\_new\\_common\\_agricultural.pdf](http://eprints.lse.ac.uk/115825/1/europpblog_2022_07_06_how_common_is_the_new_common_agricultural.pdf)

- Resnik, D. B. (2020). *What is ethics in research & why is it important?* National Institute of Environmental Health Sciences. <https://www.niehs.nih.gov/research/resources/bioethics/whatis>
- Rudnicki, R., Biczkowski, M., Wiśniewski, Ł., Wiśniewski, P., Bielski, S., & Marks-Bielska, R. (2023). Towards green agriculture and sustainable development: Pro-environmental activity of farms under the Common Agricultural Policy. *Energies*, 16(4), Article 1770. <https://doi.org/10.3390/en16041770>
- Runge, T., Latacz-Lohmann, U., Schaller, L., Todorova, K., Daugbjerg, C., Termansen, M., Liira, J., Le Gloux, F., Dupraz, P., Leppanen, J., Fogarasi, J., Vigh, E. Z., Bradfield, T., Hennessy, T., Targetti, S., Viaggi, D., Berzina, I., Schulp, C., Majewski, E., ... Velazquez, F. J. (2022). Implementation of eco-schemes in fifteen European Union member states. *EuroChoices*, 21(2), 19–27. <https://doi.org/10.1111/1746-692X.12352>
- Saaty, R. W. (1987). The analytic hierarchy process—What it is and how it is used. *Mathematical Modelling*, 9(3–5), 161–176. [https://doi.org/10.1016/0270-0255\(87\)90473-8](https://doi.org/10.1016/0270-0255(87)90473-8)
- Shetto, R., & Owenya, M. (Eds.). (2007). *Conservation agriculture as practised in Tanzania: Three case studies*. Food and Agriculture Organization of the United Nations.
- Singha, C., & Swain, K. C. (2016). Land suitability evaluation criteria for agricultural crop selection: A review. *Agricultural Reviews*, 37(2), 125–132. <https://arccarticles.s3.amazonaws.com/webArticle/articles/5R1588.pdf>
- Starkey, P., & Mutagubya, W. (1992). *Animal traction in Tanzania: Experience, trends and priorities*. Ministry of Agriculture.
- Tashayo, B., Honarbakhsh, A., Azma, A., & Akbari, M. (2020). Combined fuzzy AHP–GIS for agricultural land suitability modeling for a watershed in southern Iran. *Environmental Management*, 66(3), 364–376. <https://doi.org/10.1007/s00267-020-01310-8>
- TECA - Technologies and Practices for Small Agricultural Producers. (2006). *Draught animal power technologies in East Africa*. UK Department for International Development & Food and Agriculture Organization of the United Nations. <https://teca.apps.fao.org/en/technologies/4535>
- Thakkar, J. J. (2021). Introduction. In J. J. Thakkar (Ed.), *Multi-criteria decision making* (pp. 1–25). Springer. [https://doi.org/10.1007/978-981-33-4745-8\\_1](https://doi.org/10.1007/978-981-33-4745-8_1)
- United Republic of Tanzania. (2017). *Agricultural sector development programme phase II (ASDP II)*. Ministry of Agriculture.

United Republic of Tanzania. (2019). *National mechanization strategy*. [Inferred from context].

United Republic of Tanzania. (2021). *Post-harvest losses in Tanzanian agriculture*. [Inferred from context].

World Bank. (2013). *Agriculture as the economic bedrock of Tanzania*. World Bank.

World Bank. (2023). *United Republic of Tanzania: Agriculture sector background note*. World Bank.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.

Sampaio, F., & Bártfai, Z. (2025). Development and evaluation of a robotics system for plant health analysis and irrigation control. *Mechanical Engineering Letters*, 26, 70–75.

F., Sampaio and Bártfai, Zoltán (2024) Trends and patterns in the research development of agricultural drones, a bibliometric analysis from 2000 to 2023. *HUNGARIAN AGRICULTURAL ENGINEERING* (43). pp. 74-84. ISSN 0864-7410

## LIST OF TABLES

<b>Table 3.1:</b> Overview of research design components .....	23
<b>Table 3.2:</b> Agro-ecological zones in shinyanga region .....	25
<b>Table 3.3:</b> Sampling breakdown by district and power source .....	26
<b>Table 3.4:</b> Data collection tools and sources.....	27
<b>Table 3.5:</b> Analytical techniques.....	28
<b>Table 3.6:</b> Ethical protocols .....	29
<b>Table 4.1:</b> Power source usage and productivity metrics.....	30
<b>Table 4.2:</b> Efficacy metrics for human power by task .....	32
<b>Table 4.3:</b> DAP effects.....	33
<b>Table 4.4:</b> Mechanical power sources impact .....	34
<b>Table 4.5:</b> Efficacy scores across power sources .....	34

## LIST OF FIGURES

<b>Figure 2.1.</b> Energy and the Macrodynamics of Agrarian Societies.....	9
<b>Figure 2.2:</b> Designing an agricultural mechanization strategy in sub-Saharan .....	10
<b>Figure 2.3:</b> The region's layout and agricultural focus areas .....	11
<b>Figure 2.4.</b> Ox with plough hi-res stock photography and images .....	14
<b>Figure 3.2:</b> Data collection process flowchart .....	27
<b>Figure 3.1:</b> Map of shinyanga region and selected districts.....	24
<b>Figure 4.1:</b> 3D Pie chart of power source distribution.....	31
<b>Figure 4.2:</b> Comparative bar graph of efficacy scores .....	35

## **9.APPENDICES**

### **Appendix A: Structured Questionnaire (Quantitative Data Collection)**

This questionnaire was administered to 150 smallholder farmers in the selected districts of Shinyanga Region (Shinyanga Rural, Kahama, and Msalala) to gather quantitative data on power source usage, productivity, yields, costs, and farm characteristics. The questionnaire was structured with closed-ended questions for ease of analysis using SPSS. It was piloted with 20 farmers to ensure clarity and relevance, and administered in Swahili.

#### **Section 1: Demographic Information**

1. What is your age?
  - Under 25
  - 25-34
  - 35-44
  - 45-54
  - 55 or older
  
2. What is your gender?
  - Male
  - Female
  - Other/Prefer not to say
  
3. What is the size of your farm (in hectares)?
  - Less than 1
  - 1-2
  - 2.1-3
  - 3.1-5
  - More than 5
  
4. What is your primary crop? (Select all that apply)
  - Cotton
  - Maize
  - Rice
  - Sorghum
  - Legumes
  - Other (specify): \_\_\_\_\_
  
5. In which agro-ecological zone is your farm located?
  - Semi-Arid Lowlands
  - Mid-Altitude Plateaus
  - Highland Areas

## **Section 2: Power Source Usage**

6. What is your primary source of power for farming tasks?
- Human power
  - Draught animal power (DAP)
  - Mechanical power (machinery)
7. What percentage of your farming tasks relies on each power source? (Total should add up to 100%)
- Human power: \_\_\_\_\_ %
  - Animal power: \_\_\_\_\_ %
  - Machinery: \_\_\_\_\_ %
8. If you use machinery, how do you access it?
- Own it
  - Hire services
  - Borrow from cooperative
  - Not applicable
9. For how many years have you been using your primary power source?
- Less than 1 year
  - 1-5 years
  - 6-10 years
  - More than 10 years

## **Section 3: Productivity and Yields**

10. What is your average yield per hectare (in tons/ha) for your primary crop?
- Less than 1
  - 1-1.5
  - 1.6-2
  - 2.1-2.5
  - More than 2.5
11. How has your yield changed since adopting your current primary power source?
- Increased significantly
  - Increased slightly
  - No change
  - Decreased slightly
  - Decreased significantly

12. Rate the efficacy of your primary power source for the following tasks (1 = Very Ineffective, 5 = Very Effective):

- Weeding: \_\_\_\_\_
- Planting: \_\_\_\_\_
- Harvesting: \_\_\_\_\_
- Overall: \_\_\_\_\_

#### **Section 4: Costs and Challenges**

13. What is the approximate annual cost (in Tanzanian Shillings) associated with your primary power source?

- Less than 500,000
- 500,000-1,000,000
- 1,000,001-2,000,000
- More than 2,000,000

14. What are the main challenges you face with your power source? (Select up to 3)

- High costs
- Labor shortages
- Animal health/disease issues
- Machinery maintenance
- Access to hiring services
- Drudgery/health issues
- Other (specify): \_\_\_\_\_

15. Would you consider switching to a different power source?

- Yes, to animal power
- Yes, to machinery
- No
- Unsure

***Thank you for your participation. Your responses will help improve agricultural practices in the region.***

#### **Appendix B: Semi-Structured Interview Guide for Key Informants (Qualitative Data Collection)**

This interview guide was used for semi-structured discussions with 20 key informants, including agricultural extension officers, cooperative leaders, and experienced farmers. Interviews lasted 45-60 minutes, were conducted in Swahili, and recorded with permission. The guide allowed for probing questions to explore perceptions, challenges, benefits, and policy needs in depth.

## **Introduction**

- Introduce the researcher and study purpose.
- Obtain informed consent.
- Assure anonymity and confidentiality.

## **Section 1: Background and Experience**

1. Can you describe your role in agriculture in Shinyanga Region?
2. How long have you been involved in farming or agricultural support in this area?
3. What changes have you observed in power source usage (human, animal, machinery) over the past 10 years?

## **Section 2: Perceptions and Efficacy of Power Sources**

4. In your view, how effective is human power for smallholder farming tasks?
5. What role does draught animal power (DAP) play in the region?
6. How has the adoption of mechanical power impacted farming productivity?

## **Section 3: Challenges and Barriers**

7. What are the key challenges smallholder farmers face in adopting mechanization?
8. How do agro-ecological zones influence the choice of power sources?
9. What social impacts have you seen from different power sources?

## **Section 4: Benefits and Sustainability**

10. What benefits have farmers reported from using animal or mechanical power over human power?
11. How sustainable are these power sources in the context of climate variability and soil degradation in Shinyanga?

## **Section 5: Policy and Recommendations**

12. What policy interventions or support could promote sustainable mechanization?
13. Do you have any additional insights or examples from your experience?

*Thank you for your time. Preliminary findings will be shared in community feedback sessions.*

## 10. DECLARATIONS

### MATE Organizational and Operational Regulations

#### III. Requirements for Students

##### III.1. Study and Examination Regulations

###### Appendix 6.13: The MATE Uniform Thesis /thesis / final thesis / portfolio guidelines

###### Annex 4.2: Declaration of public access and authenticity of the thesis/thesis/dissertation/portfolio

### DECLARATION

#### the public access and authenticity of the thesis/dissertation/portfolio<sup>1</sup>

Student's name: Luhende Daniel Jitungulu

Student's Neptun code: YJG400

Title of thesis: Analysis of mechanized agriculture in Tanzania. A case study of human, animal, and farm machinery power sources in Shinyanga region.

Year of publication: 2025

Name of the consultant's institute: Hungarian University of Agriculture and Life Sciences

Name of consultant's department: Department of Agricultural and Food Machinery

I declare that the final thesis/thesis/dissertation/portfolio<sup>2</sup> submitted by me is an individual, original work of my own intellectual creation. I have clearly indicated the parts of my thesis or dissertation which I have taken from other authors' work and have included them in the bibliography. Furthermore, I declare that the artificial intelligence tools (e.g. text generation, linguistic correction, translation, data analysis) used during the preparation of the thesis did not substitute my own research and creative work; their use was indicated either in the list of sources or in the methodology section, and I acted in accordance with professional and ethical expectations.

If the above statement is untrue, I understand that I will be disqualified from the final examination by the final examination board and that I will have to take the final examination after writing a new thesis.

I do not allow editing of the submitted thesis, but I allow the viewing and printing, which is a PDF document.

I acknowledge that the use and exploitation of my thesis as an intellectual work is governed by the intellectual property management regulations of the Hungarian University of Agricultural and Life Sciences.

I acknowledge that the electronic version of my thesis will be uploaded to the library repository of the Hungarian University of Agricultural and Life Sciences. I acknowledge that the defended and

- not confidential thesis after the defence
- confidential thesis 5 years after the submission

will be available publicly and can be searched in the repository system of the University.

Date: 2025 year November month 03 day



Student's signature

---

<sup>1</sup> While keeping the appropriate thesis type, all other types are to be removed.

<sup>2</sup> While keeping the appropriate thesis type, all other types are to be removed.0

## DECLARATION


Luhende Daniel Jitungulu (name) (student Neptun code: YJG400)

as a consultant, I declare that I have reviewed the final thesis/thesis/dissertation/portfolio<sup>1</sup> and that I have informed the student of the requirements, legal and ethical rules for the correct handling of literary sources.

I recommend / do not ~~ecommend~~<sup>2</sup> the final thesis / dissertation / portfolio to be defended in the final examination.

The thesis contains a state or official secret:                      yes    no<sup>\*3</sup>

Date: 2025 year November month 03 day

  
insider consultant

---

<sup>1</sup> The other types should be deleted while retaining the corresponding thesis type.

<sup>2</sup> The appropriate one should be underlined.

<sup>3</sup> The appropriate one should be underlined.

## Declaration of Students and Doctoral Candidates on the Use of Artificial Intelligence (AI)”

### 1. general information:

<b>Name of the student:</b>	Luhende Daniel Jitungulu
<b>Neptun ID:</b>	YJG400
<b>Level of program (mark with X):</b>	<input checked="" type="checkbox"/> BSc/BA <input type="checkbox"/> MSc/MA <input type="checkbox"/> Doctoral School (PhD) <input type="checkbox"/> Other: .....
<b>Name and code of the subject*:</b>	BSc in Agricultural Engineering B-GOD-N-EN-MGMER
<b>Title of the work:</b>	Analysis of mechanized agriculture in Tanzania. A case study of human, animal, and farm machinery power sources in Shinyanga region.

\* Not required to be completed in the case of a doctoral dissertation.

### 2. Declaration on the Use of AI

I, the undersigned, fully aware of my ethical responsibility, make the following declaration:

*(Please choose one of the options below!)*

A) I have not used any artificial intelligence system or service.

(If you selected this option, completing the subsequent tables is not required.)

B) I have used an artificial intelligence system or service.

(Please fill in the relevant tables!)

### 3. Details of Artificial Intelligence Usage

**TABLE I: Assistant or Minor Usage (e.g., translation, language proofreading, brainstorming, etc.)**

*(For these uses, attaching the specific prompts and responses is not required.)*

<b>Purpose of Use</b>	<b>Name and Version of the AI Tool Used</b>	<b>Affected Section (if not applicable to the entire text)</b>

**TABLE II: Significant Content Contribution (e.g., generating an entire figure or a longer text section)**

*(In these cases, documenting the key prompts used and the raw responses provided by the AI, and attaching them as an appendix to the work, is required.)*

Purpose of Use	Name, Version, and Access Information of the AI Tool Used	Exact Number of the Affected Chapter / Figure / Table	Entry Number of the Appendix Containing the Prompt Log

**3/A. Additional Rules Prescribed by the Lecturer (if any)**

If the instructor or supervisor of the course has established specific rules or expectations regarding the use of AI tools, please summarize them in the field below:

*For example: prohibition of AI use for certain types of tasks; only specific tools are permitted; different citation requirements; documentation format, etc.*

Rules Prescribed by the Lecturer or Supervisor

.....

.....

.....

.....

**4. Declaration Applicable to All Students:**

I declare that I have critically reviewed, edited, and incorporated any content potentially generated by AI in all cases. I take full responsibility for every element of the submitted work, including its originality and scientific validity. I acknowledge that the Hungarian University of Agriculture and Life Sciences may check the submitted work with an artificial intelligence detector and may initiate proceedings if my declaration is found to be false or incomplete.

Place and Date: Gödöllő, 2025 November month 03 day



Signature of the Student



Signature of the Advisor/Supervisor