FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

National Agricultural Mechanization Strategy

(2026-2035)

December 2025

Addis Ababa, Ethiopia

National Agricultural Mechanization Strategy

(2026-2035)

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MINISTRY OF AGRICULTURE

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Empowering Ethiopia's Agriculture

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FOREWORD

In Ethiopia, agriculture remains a fundamental driver of the country's economy, accounting for approximately 32% of total GDP, employing 63% of the labor force, and generating 75% of export earnings. With 80% of the Ethiopian population residing in the rural areas, national livelihoods and economic resilience are inextricably linked to agricultural performance. The country is endowed with a vast tract of fertile land and suitable agroecology, providing an optimal environment for the sustainable production of a wide variety of crops and livestock. Currently, 66% of Ethiopia's total landmass is classified as suitable for various agricultural activities, with nearly 38.5 million hectares of agricultural lands dedicated for cultivation of crops and livestock production. Consequently, the advancement of agriculture serves as the primary engine for poverty reduction, with its performance resonating across the entire macro-economic landscape. The sector is key to achieving the targets of the Ten-Year Development Plan (2021–2030) and the Sustainable Development Goals (SDGs), specifically those aimed at eradicating hunger, ensuring food security, and promoting sustainable production through the strategic application of mechanization.

Mechanization serves as a critical catalyst for agricultural modernization and rural transformation. By augmenting traditional methods with mechanical power, these technologies exponentially enhance land and labor productivity while modernizing both crop and livestock value chains. Despite this potential, farming communities in Ethiopia continue to face barriers in accessing the technologies essential for efficient

operations. Consequently, the National Agricultural Mechanization Strategy (2026–2035) has been developed to address the gaps identified during the implementation of the previous ten-year cycle (2014–2024). This strategy is rooted in the National Agricultural and Rural Development Policy and aligns with Ethiopia's Ten-Year Development Plan, the Malabo Declaration, the AU Agenda 2063, and the framework for Sustainable Agricultural Mechanization in Africa.

The strategy prioritizes the establishment of an enabling environment by instituting favorable policies, enhancing institutional capacity, and fostering seamless multi-sectoral coordination. It seeks to strengthen agricultural mechanization research, innovation, extension, and training while promoting digitalized and diversified mechanization service provision. Key initiatives include expanding access to credit, incentivizing and popularizing domestic manufacturing and assembly plants, and promoting mechanization technology designed to reduce pre-harvest, harvesting, and post-harvest losses. By empowering farming communities and catalyzing rural industrialization, these shall secure a path toward sustainable agricultural growth.

The strategy provides clear directions for current and future interventions, fostering sustainable growth and the systematic transformation of agricultural mechanization across the nation. I am confident that through the integration of government institutions and private stakeholders and robust monitoring and evaluation systems, the goals of this strategy shall be realized. Finally, I commend the collaborative efforts of all

stakeholders who contributed to the formulation of this strategy. Its ultimate success now hinges on coordinated implementation across federal and regional levels. Let us work together to build a mechanized and climate-resilient agricultural sector that drives Ethiopia's prosperity.

H.E. Addisu Arega
Minister, Ministry of Agriculture
Federal Democratic Republic of Ethiopia

Message from the State Minister for Agricultural Investment and Inputs

It is worth emphasizing that one of the main tenets of our national prosperity agenda is the transformation of Ethiopian agriculture from a traditional, subsistence-based sector to a contemporary, market-driven economy. The development and execution of the National Agricultural Mechanization Strategy, which provides a comprehensive framework to shift our farming practices from a heavy reliance on hand tools and animal traction to an effective, inclusive, and technology-driven production system, marks a significant turning point in this journey. To achieve this goal, the strategy is intended to penetrate every aspect of the industry, including crops, livestock, forestry, irrigation, fisheries, and post-harvest value chains, guaranteeing that mechanization serves as a catalyst for resilient and sustainable growth in the rural economy.

This strategy acts as a blueprint for a structural change in the way we produce, process, and compete in the global market by establishing forward-looking strategic priorities in the areas of research and innovation, mechanization manufacturing and assembly, service provision, institutional and human capacity development, and the development of smart and precision agriculture. It is more than just a document; it represents a bold call to collective action and a shared national commitment. Its success hinges on the coordinated efforts of all parties involved in the agricultural ecosystem to convert these goals into real impact on the ground.

I urge our farmers, semi-pastoralists, and pastoralists to embrace mechanization as a crucial means of increasing output, reducing the strain of manual labor, and ensuring stable livelihoods. I implore private sector partners, such as importers, manufacturers, and assemblers, to give top priority to providing high-quality, reasonably priced, and context-appropriate technologies along with dependable after-sales support. In order to ensure inclusive growth throughout the industry, I also urge financial institutions and investors to expand creative financing and leasing models that give youth, smallholders, and cooperatives access to machinery.

Additionally, I urge extension systems, research organizations, and agricultural professionals to lead the shift to evidence-based technology and innovation, capacity building, and advisory services. In order to ensure that technological solutions are adapted to Ethiopia's various agro-ecologies and farming systems, your role is crucial. Simultaneously, regional and local governments should incorporate mechanization into their strategic and annual plans and work closely with development actors to ensure its successful implementation.

When implemented responsibly, mechanization is a powerful driver for increasing production and productivity, rural industrialization, job creation, and the empowerment of women and youth in rural areas. Let us therefore work together with unity, responsibility, and determination to translate this strategy into meaningful change on the ground. The Ministry of Agriculture remains fully committed to providing leadership,

coordination, and an enabling environment to realize a modern, productive, and resilient agricultural sector for Ethiopia.

Finally, I would like to mention that mechanization can significantly boost output and productivity, rural industrialization, the creation of jobs, and the empowerment of rural women and youth. Therefore, let's collaborate with solidarity and accountability to turn this strategy into significant change on the ground.

H.E. Dr. Sofiya Kassa
State Minister for Agricultural Investment and Inputs
FDRE Ministry of Agriculture

ACKNOWLEDGEMENTS

The development of the National Agricultural Mechanization Strategy had been a collaborative endeavor, shaped by the dedication and expertise of multiple stakeholders. In presenting this strategy, I wish to take this opportunity to express my sincere gratitude to all who contributed to this great work. It is through their commitment and hard work that this milestone has been made possible.

First and foremost, I would like to thank the GIZ Ethiopia for supporting this strategy financially from commencement to validation of the project. I am also grateful to AGRA, FSRP, and the Nutrition project for their financial support during the strategy's development.

I would further like to acknowledge the members of the steering and technical committees. Their tireless dedication, unwavering commitment, and indispensable technical expertise were fundamental in drafting, refining, and managing this strategic document from inception to completion.

Ultimately, the successful completion of the strategy was made possible through the collaborative efforts of the reviewers and all stakeholders who provided their comments in different stages of document evaluation and consultations.

Ministry of Agriculture

ACRONYMS AND ABBREVIATIONS

AMS	Agricultural Mechanization Strategy
AAMI	Adama Agricultural Machinery Industry
AMEA	Agricultural Mechanization Extension Agents
AMSE	Agricultural Mechanization Service Enterprise
AMT	Agricultural Mechanization Technology
ARC	Agricultural Research Centers
ARDP	Agricultural and Rural Development Policy
ASTU	Adama Science and Technology University
ATDC	Agricultural Technology Demonstration center
ATVET	Agricultural Technical and Vocational Education Training
AU	Ambo University
AU	Africa union
ARDU	Arsi Rural Development Unit
ADLI	Agricultural Development-Led Industrialization
ATA	Agricultural Transformation Agency
ACE	Agricultural Cooperatives in Ethiopia
AI	Artificial Intelligence
BC	Before Birth of Christ
BDU	Bahir Dar University
CADU	Chilalo Agricultural Development Unit
CBU	Complete Build Up
CC	Customs Commission
CAADP	Comprehensive Africa Agriculture Development Program
CIMMYT	Center for International Maize and Wheat Improvement
CSA	Central Statistic Authority
CSC	Civil Service Commission

CSS	Central statistical service
DBE	Development Bank of Ethiopia
DA	Development Agent
EAA	Ethiopian Agricultural Authority
EFCCC	Environment, Forest, and Climate Change Commission
EIAR	Ethiopian Institute of Agricultural Research
EPRDF	Ethiopian People Revolutionary Democratic Front
ERA	Ethiopian Road Authority
EOS	Ethiopian Occupational Standard
EAMS	Ethiopian Agricultural Mechanization Service
FAO	Food And Agricultural Organization of the United Nation
FTC	Farmers Training Center
FOREX	Foreign Exchange
F-SAM:	Framework for Sustainable Agricultural Mechanization in Africa
GDP	Growth Domestic Product
GERD	Great Ethiopian Renaissance Dam
HGEDP	Home Grown Economic Development Plan
FCU	Farmer cooperative union
GIS	Geographic Information System
GPS	Global Positioning System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
HLI	Higher Learning Institutes
HRU	Haramaya University
HWU	Hawasa University
HGEDP	Home Grown Economic Development Plan
IFPRI	International food policy Research institute
ILRI	International Livestock Research Institute

ITA	International Trade Administration
ICT	Information and Communication Technology
METEC	Metals and Engineering Corporation
MoA	Ministry of Agriculture
MoE	Ministry of Education
MoF	Ministry of Finance
MoFED	Ministry of Finance and Economic Development
MoLI	Ministry of Lowland and Irrigation
MoM	Ministry of Mines
MoP	Ministry of Planning
MoLS	Ministry of Labour and Skill
MoTL	Ministry Of Transport and Logistics
MoWIE	Ministry of Water, Irrigation and Electricity
MPP	Minimum Package Program
MTDC	Mechanization Technology Demonstration Center
NAMS	National Agricultural Mechanization Strategy
NAMSC	National Agricultural Mechanization Steering Committee
NAMTC	Agricultural Mechanization Technical Committee
NTAP	Nazareth Tractor Assembling Factory
NBE	National Bank of Ethiopia
NDDS	National Data Dissemination System
NDP	National Development Plan
NEP	National Electrification Program
NGOs	Non-Governmental Organizations
OECD	Organization for Economic Cooperation and Development
PTO	Power Take-off
R&D	Research and Development
RAB	Regional Agriculture Bureau

RTA	Road Transport Authority
R&D	Research and Development
SIDA	Swedish International Development Agency
SKD	Semi-Knocked Down
SME	Small and Medium Enterprises
SMS	Subject Matter Specialists
SWOT	Strengths, Weaknesses, Opportunities, Threat
SE4ALL	Sustainable Energy for All
SDG	Sustainable Development Goal
UNs	United Nations
UNECA	United Nations Economic Commission for Africa
URRAP	Universal Rural Road Access Program
USAID	United State Agency for International Development
UNIDO	United Nations Industrial Development Organization
VAT	Value Added Tax
WASH	Water, Sanitation and Hygiene
WADU	Wolayta Agricultural Development Unit
WRB	World Reference Base for Soil Resources
WTO	World Trade Organization
WU	Wollaga University
2WT	Two-Wheel Tractor
4WT	Four-Wheel Tractor

EXECUTIVE SUMMARY

Agricultural mechanization refers to the economic application of engineering technology to increase production efficiency and effectiveness, as well as land and labor productivity. It encompasses the provision and utilization of all power sources for agricultural land development, crop and livestock production, harvesting, storage, and product processing. Mechanization also includes manufacturing, distribution, repair, maintenance, management, and the effective use of agricultural tools, implements, and machinery. Moreover, on-farm processing, irrigation systems, and related technologies and tools also constitute mechanization. Despite its critical role in modernizing agriculture, the adoption and application of mechanization technologies in Ethiopia remain limited across crop, livestock, and natural resource value chains.

The first National Mechanization Strategy, implemented between 2014 and 2024, played a pivotal role in enhancing agricultural efficiency and productivity, reducing post-harvest losses, and advancing the country's agricultural development goals. Despite these significant contributions, however, emerging challenges, including a declining agricultural labor force, rising labor costs, the demand for food self-sufficiency, and the increasing need for high-quality agricultural produce, have created the necessity to revise the former strategy and develop a new mechanization strategy. Furthermore, evolving national development programs, the ten-year sectoral strategy and development initiatives, emerging agricultural technologies, and the growing interest of the private sector in supplying

and introducing mechanization solutions across crop, livestock, and natural resource value chains further underscore the importance of revising the previous national agricultural mechanization strategy.

Pursuant to this, the strategy defines a transformative vision for the nation's agricultural landscape over the coming 10 years. By 2035, we aspire to see a mechanized agricultural production system that contributes to the country's economic development and prosperity. The strategy seeks to optimize agricultural efficiency, maximize productivity and total output, and significantly reduce production losses, thereby ensuring sustainable livelihoods through the adoption of appropriate and innovative agricultural mechanization technologies.

The present strategy was developed by drawing on evidence acquired and lessons learned from the execution of previous strategies, analysis of primary and secondary sources of information, and the experiences of other countries. In its formulation, the strategy carefully evaluated and considered the country's present agroecology, topography, slope, development potentials, and primary agricultural systems, including crop production, irrigation, and animal production. Institutional coordination and capacity for agricultural mechanization were thoroughly addressed. This included considerations of mechanization structure, agricultural mechanization extension service, mechanization research and technology development, training and capacity building programs, agricultural machinery testing and certification, financial institutions and access to finance for mechanization, agricultural mechanization services

provision, agricultural machinery manufacturing, import, and after-sales services, and rural infrastructure.

In addition, the strategy was aligned with key policy environments and frameworks, such as the FDRE Agricultural and Rural Development Policy (ARDP), the ten-year development plan (2021-2030), the Malabo Declaration, the Sustainable Development Goal (SDG) of Ethiopia, the African Union (AU) Agenda 2063, Sustainable Agricultural Mechanization in Africa (F-SAMA), and the tax incentive on agricultural mechanization technologies and services. In a nutshell, a comprehensive SWOT analysis was carried out to gain a deeper understanding of the current situation and identify strategic issues and challenges that would be addressed by the interventions stated in the strategy.

The goals stated in the national mechanization strategy are planned to be achieved through seven strategic pillars. The first pillar focuses on improving institutional capacity and multi-sectoral coordination and integration for agricultural mechanization. The second pillar aims to strengthen agricultural mechanization research, innovation, extension, and training. The third pillar is agricultural mechanization service provision, which aims to promote and strengthen digitalized and diversified agricultural mechanization service provision across the production system. The fourth pillar is digital agriculture, precision farming, and AI enhancing the application of digital agriculture, precision farming, and AI applications in agricultural mechanization. The fifth pillar is financial services and investment, which intends to

improve financial support and access to credit services for agricultural mechanization technologies along the value chain.The sixth pillar is agricultural mechanization technologies manufacturing and assembly plants, which aims to initiate and collaborate to establish manufacturing and assembly plants through public-private partnership. The last pillar is cross-cutting issues in agricultural mechanization. It aims to ensure agricultural mechanization initiatives respond to the diverse needs and resource bases of several segments of society and climate change and the environment.

Finally, the National Agricultural Mechanization Strategy (NAMS) is not intended to be a mere ornament; it is designed to be implementable and actionable to achieve its stated goals. Its successful implementation requires active involvement and coordination of multiple stakeholders. To ensure impactful results, robust monitoring and evaluation mechanisms have been established to guarantee that planned strategic interventions are implemented effectively and efficiently.

PART ONE
INTRODUCTION

1.1. Overview of Ethiopian Agriculture

Ethiopia is a country in the Horn of Africa that covers over 1.1 million square kilometers (426,000 square miles), making it one of Africa's largest countries with a diversified topography and abundant wildlife (HAS, 2022). The country, with over 112 million inhabitants (2019), is the second and the 13th most populous country in Africa and the world, respectively, with an annual population growth rate of 2.6% (2019) (World Bank, 2021; UNECA, 2023). The Ethiopian economy is primarily sustained by the agriculture sector. Over the past years, the country has experienced rapid and high economic growth, with Gross Domestic Product (GDP) growing by an average of 8.1% per year in 2023/24, with agriculture growing at an average annual rate of 7% and crop and livestock sub-sectors growing by 7.8% and 5.3%, respectively (NBE, 2024).

Ethiopia has great agricultural potential, with more than 66% of its total land area being suitable for various agricultural activities due to its diverse agro-ecologies, fertile soils, and favorable climate for producing a wide range of crops and engaging in numerous agricultural activities. Currently, Ethiopia used nearly 38.5 million hectares of agricultural land for the cultivation of crops and animal production in 2020 (Statista, 2024), which corresponded to over 34% of the country's total land area. Ethiopia is endowed with substantial water resources and is home to the headwaters of several transboundary rivers, implying a significant

potential for agriculture and livestock production. The country has 12 river basins with an annual runoff volume of 122 billion m^3 of water and an estimated groundwater potential of 2.6 - 6.5 billion m^3, resulting in an average of 1575 m^3 of physically accessible water per person per year (Seleshi *et al*., 2007).

In Ethiopia, agriculture remains an important driver of economic growth in the country's economy, accounting for around 32% of total GDP, employing 63% of the people, and generating 75% of export earnings (World Bank 2024). According to the ITA (2024), crop and livestock production account for roughly 65% and 25% of Ethiopia's agricultural GDP, respectively. Cereals, particularly teff, wheat, maize, sorghum, and barley, are the most important sources of livelihood for the ever-increasing population of the country (Fisseha et al., 2021). On average, over 29 million tons of cereals are produced yearly, with maize, wheat, teff, and sorghum accounting for 37%, 20%, 19%, and 12% of total cereal output, respectively (CSS, 2022). The country also has favorable and diverse agro-ecological zones, which make it ideal to produce several horticulture crops. Smallholder farmers covered approximately 99% of the horticultural crop production area, producing 428,752 tons of fruits and 2,107,292 tons of vegetables each year (MoA, 2023). Potatoes accounted for 46% of the vegetable-producing areas, followed by peppers and sweet potatoes, while avocado, banana, orange, papaya, and guava are common fruits growing in the country.

Ethiopia ranks first in Africa and 5th globally in terms of livestock population, with 70.3 million cattle, 42.9 million sheep, 52.5 million

goats, 8.1 million camels (CSA, 2021), and 59.5 million poultry (CSA, 2019). The study conducted by ILRI (2011) indicated that the total milk production from indigenous cows was 13.5 billion liters, camels 8.7 billion liters, crossbreed cows 5.8 billion liters, goats 326 million liters, and exotic cows 314 million. Whereas, poultry production is one of the livestock sectors with a significant contribution for livelihood and the national economy. There are about 57 million birds available in the county. Out of these birds, 34.26% are laying hens and 32.86% are broilers, which produce around 77,000 tons of meat annually (Veterinary Magazine, 2024).

Besides, Ethiopia is renowned for its bee farming potential, highly diverse honey flora, and number of colonies available, which is estimated to be over 10 million colonies. Annual beeswax production in the country is estimated to be about 3,800 tons. However, various sources estimate the annual production potential to be 500,000 tons of honey and 50,000 tons of beeswax (GBN, 2020). The country also has a big and untapped potential for fishery production. The potential of the country is estimated to be 94,541 tons annually for the main water bodies like rivers, lakes, ponds, and reservoirs (Abdulhakim and Alemayehu, 2020).

Despite the immense potential of the country for agricultural and livestock production, however, both are carried out using traditional tools and animal-drawn equipment; hence, with a high degree of post-harvest losses, it is resulting in low levels of efficiency, productivity, quality, and volume of production. The use of modern technology and mechanization is, therefore, a vital approach for ensuring agricultural efficiency and

sustainability, as well as achieving food system transformation in the country.

1.2. Historical background of Agricultural mechanization in Ethiopia

Agricultural mechanization is the economic application of engineering technology to enhance the effectiveness and productivity of land and human labor (FAO & UNIDO, 2008). It involves the provision and use of all forms of power sources for agricultural land development, crop and livestock production and natural resource management, harvesting, storage, and on-farm processing of products. The manufacture, distribution, repair, maintenance, management, and utilization of agricultural tools, implements, and machines are under this discipline. Mechanization also includes irrigation systems, on-farm processing, and related technologies and equipment. The historical background of Ethiopian agricultural mechanization development during the eras of various national governments has been briefly discussed below.

Agricultural Mechanization during the Imperial Regime (Before 1974): Modern agricultural mechanization development interventions were started during the late 1950s and early 1960s. The development strategies then were paying attention to supporting medium- to large-scale capital-intensive private farms producing cereals like wheat and other cash crops (Cohen, 1987). Hastened by three successive five-year plans of the Imperial time, the period saw government encouragement of engine-driven mechanization (Adams 1970; Zewde 1991). The first five-

year plan (1957–1961) gave barely any attention to agriculture, let alone mechanization. The first university program in agricultural engineering started in 1959 at the then Alemaya (now Haramaya) University, and the Jimma Agricultural Technical School followed suit, opening at about the same time to train agricultural engineers and extension workers. Similarly, Agro Mechanic Department was established in Bahir Dar Polytechnic College in 1963 with the help of the Soviet Union. The second five-year plan (1962-1966) gave particular focus to large-scale private commercial farms, where over 50% of the budget allocated to the sector went to supporting them (Adams 1970). Consequently, although geographically not evenly distributed, some high-profile large-scale private farms run by Ethiopians and expatriates emerged, including some in Setit Humara and the Tendaho cotton plantations, run by the British Mitchell Cotts Company in the Rift Valley (Zewde 1991; Kelemu 2015). The government was also an agent of mechanization, running large farms such as the Awash Valley Authority (Zewde 1991).

Like its predecessor, the second five-year plan effectively bypassed smallholder farmers and it was not until the third five-year plan (1969-1973) that work started on an area-based smallholder development strategy. A prototype of such area development was the Chilalo Agricultural Development Unit (CADU), which was set up in 1967, provided 73,000 families with access to a package of inputs, consisting of fertilizer, improved seeds and feeds, improved farm implements and access to credit and markets (Adams 1970).

Agricultural Mechanization during the Derg Regime (1974-1991)*:* The military-cum-socialist government reversed the direction of farming in favor of cooperative and state farms. Some 448 state farms were set up, many of which were nationalized private farms (Kelemu 2015). Large-scale state and cooperative farms would, it was thought, improve productivity and bring about broader economic growth (Berhanu 2016). The Derg's drive towards large-scale mechanized farming was epitomized by its setting up of the Adama Tractor Factory in 1984. Likewise, the Agricultural Equipment and Technical Service Enterprise was set up for the purchase and distribution of agricultural and construction equipment (Kelemu 2015). However, because of poor farm management and poor choice of machinery, the tractors and combine harvesters faced frequent breakages and oil leaks, and consequently the Derg's experience was largely a failure (Kelemu 2015). In addition, the bulk of smallholder farms that were not drawn into cooperatives experienced decline due to neglect and adverse policies such as low farm gate prices (Berhanu 2016). However, CADU was expanded to the province level as the Arsi Rural Development Unit (ARDU), and one of its purposes was to meet the increasing demand for farm machinery in Arsi and the neighboring province of Bale.

Following CADU, the Wolaita Agricultural Development Unit (WADU) was set up to deliver a similar package. Apart from Assela (in the CADU area) and Sodo (in WADU area), Eight dedicated mechanization rural technology promotion centers were established in Kombolcha, Mekele, Bako, Jimma, Bahir Dar, and Harar. These centers aimed at

promoting rural mechanization, and many have argued that the diffusion of implements (such as improved ploughs and carts) still used today on farms across Ethiopia have their origins in these mechanization centers (MoA, 2017; Kelemu, 2015).

Agricultural Mechanization during EPRDF: After the EPRDF came to power in 1991, due emphasis was not given to agricultural mechanization. The EPRDF focused on an optimum combination (or allocation) of capital, labor, and land as a critical condition for economic development. Moreover, it stressed that apart from large-scale commercial farms in less populated lowland areas, smallholder agriculture should remain dependent on labor and animal traction.
EPRDF's proposition on mechanization became part and parcel of the ADLI strategy. After ADLI became the government's official development strategy in 1993, apart from a few donor-led efforts and limited private operations, mechanization-related institutions and practices either stalled or were shelved. The department coordinating mechanization at the Federal Ministry of Agriculture (MoA) restructured, and degree programs in agricultural engineering at higher education institutions were reduced (MoA, 2014).

But the Agricultural Mechanization Research Directorate was restructured into the Ethiopian Institute of Agricultural Research in 2000, and, in parallel, restructuring took place at the regional level (MoA/ATA 2014). Even if mechanization was low on the policy agenda, a few donor programs and private sector activities promoted smallholder

mechanization. These include the Sasakawa Global-2000, which successfully promoted different post-harvest technologies, notably stationary multi-crop threshers and maize shellers, and the Ethio-German Agricultural Training Centre at Kulumsa which trains technicians and farmers on the use of modern agricultural machines (MoA, 2017).

Current scenario of agricultural mechanization (2019-2024): After 2018, there were magnificent changes brought to agriculture. Since the current government came to power as of 2018, so many government initiatives have been initiated to modernize farming systems. The establishment of Kegna Agricultural Equipment Manufacturing, Woreta International Business companies, Jebdu Motors, Amhara Basic Metal Corporation, etc., was among the initiatives to mass import Semi-Knocked Down (SKD) and assemble agricultural tractors and irrigation pumps, which played a great role in increasing the level of agricultural mechanization of the country.

All agricultural mechanization technologies are exempted from any customs duty and tax, including VAT of mechanization services. FOREX and local currencies were provided to most agricultural machinery importers in order to increase and motivate mechanization. Facilitating financial access for smallholder farmers, who have two or more hectares, to own agricultural machinery with minimum possible credit without requesting collateral of permanent property for credit guarantee. The farmers have benefited from rural land administration and use the proclamation to have a certificate of their own land, and the

certificate serves the farmers to ensure ownership to request machinery and assets for collateral. Besides, the machinery lease finance program was facilitated for farmers through the Development Bank of Ethiopia. In doing so, the number of tractors, combine harvesters, and irrigation pumps increased to 19,692, 2,700, and 474,150, respectively (MoP, 2023). Since then, agricultural production and productivity have been increasing from time to time. To give attention to agriculture mechanization, the Agricultural and Rural Development Policy was designed. Apparently, the National Agricultural Mechanization Strategy was also developed to change the existing scenario of farming systems, both in crops and livestock. Development partner support in agricultural mechanization has increased more than ever. Most importantly, the government has a great commitment to work on mechanization.

Currently, the government started different initiatives, which enhance agricultural production and productivity. The rice flagship initiative, wheat initiative, Enset flagship, and *'Yelemat Terufat'* are among the major initiatives of the governments. These initiatives motivated the farmers and other farming community to implement cluster farming in crop and livestock production. The approach of cluster farming boosts the need for and use of agricultural mechanization, which contributes to agriculture production increment and reduction of post-harvest losses.

1.3. Rationale of strategy

Over the past ten years, several changes have occurred, including rapid population growth, urbanization due to migration of rural youth

to cities, a decline in the rural labor force, an increase in rural labor costs, an increase in demand for food supply, and a change in national and global standards for quality agricultural products for domestic and export markets, all of which have triggered the need for and use of efficient and diverse mechanization technologies. Furthermore, for the private sector to actively participate in developing and introducing various mechanization technologies across the crop and livestock value chains, an enabling policy environment and institutional arrangements are required, which necessitate revising the previous strategy while taking into account the existing dynamics and developing a new national agricultural mechanization strategy that can address emerging challenges and capitalize on opportunities. Thus, the previous strategy has been revised to take into account global (full WTO accession), regional (joining the African free trade zone), and national socio-economic dynamics and policy reforms, as well as emerging challenges/opportunities. This new national agricultural mechanization strategy has been developed to achieve the changes from hand tools and animal traction to the desired level of mechanization. The strategy involves the use of mechanization with automated systems, with a progressive introduction and affordability to achieve the desired transformation in the agricultural sector and the entire food system of the country.

PART TWO
STRATEGY PREPARATION APPROACH

The strategy development process encompasses a systematic four-stage process, as elaborated below, which emphasizes evidence-based assessment and robust stakeholder engagement along the development process.

Review and gap analysis: Prior to strategy document development, the former Agricultural Mechanization Strategy was reviewed, and the existing gaps were identified to make the strategy that shall address those gaps.

Conduct a comprehensive value chain appraisal: Using primary and secondary sources of information and data, the status of the agricultural mechanization value chain, which is pertinent to mechanization, was investigated. During the appraisal, key information about the utilization of mechanization technology and availability of technology throughout the crop production value chain (pre-harvest, harvest, post-harvest, and agro-processing), livestock production systems, post-harvest, dry land and irrigation systems, and natural resources was identified. In addition, data of service providers, dealers, pastoralists and agro-pastoralists, manufacturers, importers and assemblers, and mechanization technologies research centers were collected.

The secondary data were collected from relevant sources, sectoral strategic plans and annual reports, books, international journal articles, Ethiopian

Central Statistical Services, and international and national organizations. Collected data, such as farm and production characteristics, farm power for crop production machinery, fruit and vegetable mechanization technology, livestock production systems, service providers, type of technology used, adequacy of after-sales service, roads, fuel, and associated issues, were used throughout the strategy document development. In general, the current situation of mechanization and mechanization level, farming systems, the mechanization value chain, and experiences of benchmarking countries were identified and used.

Strategy formulation and drafting: the new strategy was developed using the procedures outlined below. The team of professionals was deployed to review former NAMS. The strengths, weaknesses, and gaps were identified. Based on the review results, the new NAMS was developed by setting vision, mission, goals, and objectives using recommendations of the previous strategy review result, farming systems, mechanization value chain, current mechanization level, and experiences of other countries.

Evaluation, refinement, and launching: The NAMS, which was drafted by the technical committee, evaluated by professionals, and refined further with the active engagement of stakeholders. After incorporating all the inputs, the final draft document was presented to top-level management at the Ministry of Agriculture for feedback and next-level leadership approval. Following approval by the MoA's top leaders, the strategy was validated and launched in a workshop attended by relevant public, private, and development partners.

PART THREE
SITUATION ANALYSIS

3.1. Status of agricultural mechanization in Ethiopia

According to a 2024 quick assessment conducted by the national strategy formulation team on agricultural mechanization status, it has been observed that most of the farmers in the country practice primary and secondary tillage operation with traditional means, while the remaining use tractors and walking tractors at least for tillage operation, respectively. Most of Arsi, Bale, Jima, East Shoa, and Somali regions are practicing primary and secondary tillage operations using tractor-drawn implements. Farm power used for harvesting operations is combine harvesters and human power. In some areas, walk-behind tractors and cereal reapers are used as alternative technology for land preparation and harvesting operations, respectively.

Despite the low annual growth rate of agricultural machinery in the country, the number of tractors increased from 12,500 (2014) to 21,666 (2025), showing 73.33% growth in tractor availability within the last 11 years. This has contributed to an overall increase of the level of mechanization from 0.5 tractors/1000 ha (2014) to 1.34 tractors/1000 ha. Emerging agricultural machinery suppliers/companies, like Kegna, Adama, and Woreta, have a significant role in the above tractor import figures (Annex 4 and 5). Likewise, during the same period, the number of combine harvesters, threshers, and irrigation pumps increased to 10,722, 18,234, and 506,112, respectively (MoP, 2023 and MoA, 2024). However, only a few companies have contributed to the existing

combined figure. Unlike combine harvesters and threshers, the number of knapsack sprayers, hermetic bags, seed cleaners, and tractor-drawn trailers (MoA, 2023) has increased to 852,038, 2,807,067, 86, and 3,006, respectively.

When we analyze mechanization use status under different farm operations, it is 13.4 tractors, 6.6 combiners, 10 threshers, and 521 knapsack sprayers per hundred-kilometer square (100 km²) of arable land, respectively (MoA, 2023). Global estimates indicate 200 tractors on average for every 100 km² of arable land (Steenwyk et al., 2022). Whereas in Sub-Saharan Africa, there are 27 tractors per 100 km² of arable land. In Kenya there are 27 and in Zambia 23 tractors per 100 km² (World Bank, 2014). In general, as compared to other developing countries, the level of mechanization for pre-harvesting, harvesting, and post-harvesting mechanization in our country is still very low (Hello Tractor, 2023).

Despite immense potential in the livestock sector, the number of livestock mechanization technologies promoted to the farming system is very limited. According to the MoA report of 2016 EC, the number of grass mowers is about 67, balers 27, animal feed choppers and mixers of different sizes 2,670, haymaking machinery 1,030, animal production technology such as incubators, chicken feeders, cages, etc. is assumed to be 28,649, milk product processing equipment (milking machines, churners, and milk cans) is 22,844, beekeeping equipment (modern beehives and honey extractors) is 828,752, poultry production equipment is 66,195, and fishery production and processing equipment is 798.

3.2. Agro-ecological, topography and slope of the country

Ethiopia is divided into 19 major and 48 sub agro-ecologies; the major ones are characterized as cold to very cold, humid, sub-Afro-alpine to Afro-alpine, hot to warm arid lowland plains, tepid to cool arid/humid/moist mid highlands, tepid to cool/humid/moist sub-humid to cool and sub-moist highlands, and water bodies. The detail is indicated on the map immediately below and estimated to cover over 12,486,270 ha from the total arable land. The agro-ecological classification is generated by superimposing different maps like soil association, contour, elevation, slope, temperature, rainfall, land use land cover, vegetation, river basins, and crop suitability, including road networks (MoA, 1998).

Topography: Different crops and livestock thrive at different altitudes. Essentially, low elevation makes for hotter temperatures and less rainfall; higher elevations are cooler and wetter, and the middle elevations are moderate and convenient for farming. The great majority of rural Ethiopians live in the middle highlands and highlands, where sufficient rainfall exists. Even though the country has complex relief, it can be classified into five topographic features. These are the Western highlands, the Western lowlands, the Eastern highlands, the Eastern lowlands, and the Rift Valley. The Western Highlands are the most extensive and rugged topographic component of Ethiopia.

The highland core is encircled by semi-arid lowlands. The highlands of the country have massive mountains situated in the Horn of Africa with significant physical features, which form the largest continuous

areas of elevation. Hence, highlands have high potential for upland crops and forest mechanization, while most of the lowlands have high potential for irrigation, using surface and underground water & livestock production. Middle lands have high potential for farming and livestock mechanization systems. But what matters most is the way we map to use mechanization technology as per the topography and slope of the terrain.

Slope: In Ethiopia topographic slopes were classified into three major categories. The first one is from 0 to 8^0 slope, which comprises 56% of the total area of the country and is suitable to use all ranges of machinery. The second category of slope is 8-15^0, which comprises 12.2% of the area of the country. Such undulating topography requires special machinery and a huge amount of money for land development to make it suitable for mechanization and irrigation. The 3rd category of slope is above 15^0, which is characterized by steepness and is not suitable for some mechanization technologies, but currently steep and moderately steep areas are used for farming by the highlanders, i.e., the smallholder farmers of the country (MoA, 1998).

Soil conditions: The existence of diverse environments resulted in 21 soil types. Indigenous soil classification in the country is as old as agriculture. Currently, the F(WRB) is widely practiced. Significant amounts of fertile topsoil are lost due to water erosion. 43% of the arable land of the country is affected by soil acidity that is either strongly or moderately acidic (Amanuel, 2024), and about 10% of the total land area is also affected by salinity and/or sodicity (Sheleme, 2023). The

country stands first in Africa in the extent of salt-affected soils. About 44 million ha (36% of the total land area) are potentially susceptible to salinity problems, of which 11 million ha have already been affected by different levels of salinity. Soil sodicity is the problem of dry areas in Ethiopia, mainly Afar and northern parts of the Somali Regions. About 4,250 km² of sodic soils exist in Ethiopia (Alemayehu *et al*., 2023).

The different soil types of the country show great variation in their morphological properties, such as depth, color, structure, and consistency. Across the country, the sand content varies from 1 to 75%; silt, from 9 to 60%; and clay, from 10 to 86%. The clay content of Ethiopian soils ranges between 10 and 86%. About 48.65% of the country's total area is covered by soils whose clay content is greater than or equal to 35% (Alemtehu *et al*., 2023).

When it comes to soil chemical properties, soil reactions in Ethiopian soils can be broadly grouped into three categories. The soils in the highlands of the northwestern, western, and central parts of Ethiopia are predominantly acidic. The Rift Valley, the lowlands of eastern and southern regions, and the arid dry highlands of Tigray are dominated by alkaline soils (Alemtehu et al., 2023). Furthermore, the soils of Ethiopia can be classified into five principal types. The first one is composed of eutric nitosols and andosols, which are found on the western and eastern highlands of Ethiopia. These soils have medium to high potential for rain-fed agriculture. The second group of soils, eutric cambisols and ferric and orthic luvisols, are found in the Northern Plateau of the

Western Highlands of the country. They have a high accumulation of clay with low nutrient retention, surface crusting, and erosion hazards. This group of soils has medium agricultural potential. The third group of soils is vertisols, the dark clay found in the Western Lowlands and at the foothills of the Western Highlands of Ethiopia. It is also partly found in the central part of Ethiopia. The soil is characterized by expansiveness in nature during the wet season and shrinkage during the dry season. Hence, it is difficult for tillage because it gets hardened when dry and sticky when wet.

They have medium to high potential for agriculture. Some of the rich coffee-growing regions of Ethiopia are found on these soils. The fourth group is composed of yermosols, xerosols, and other saline soils, which are found at the easternmost, hottest lowlands of Ethiopia. Such soil is characterized by moisture stress and has less potential for rain-fed agriculture. However, the wetter margins are excellent for livestock, and the drier margins are convenient for irrigation. The fifth soil group is lithosols, found primarily in the Denakil Plain. Lack of moisture and shallow profile preclude cultivation of these soils.

Based on the phyco-technical characteristics of the soil and its unit resistance to the attached implements during land preparation, an appropriate horsepower tractor and corresponding implements are selected for efficient use of machinery and quality of work for optimized use of inputs and reduction of cost of operation.

Agricultural engineers should advise the farmers on the selection of tractor power required and matching implements like plow type (disc or moldboard) regarding their width, desirable depth, weight, and number of plow bottoms or attached implements for land preparation. Based on the unit soil resistance (kg/cm²) of the following agricultural soils (sandy soil, 0.2; sandy loam, 0.3; silt loam, 0.35-0.5; clay, 0.4-0.58; heavy loam, 0.5-0.7; heavy clay soil, 1.0-1.4), which are widely distributed along the agricultural fields of Ethiopia (Jain & Philip, 2006).

3.3. Natural resources potentials

Ethiopia has immense natural resource potential, like water, energy, forests, etc. The country constitutes 99.3% of the land area, and the remaining 0.7% is covered with water bodies. It also has a substantial amount of water resources with 12 basins, 8 of which are river basins, 1 lake basin, and the remaining 3 are dry basins. The surface water potential is 124.4 billion cubic meters, of which 70 billion cubic meters is from lakes. Like surface water, the country has huge groundwater potential, which is estimated to be 185 billion cubic meters. All water surface and groundwater potential are important to use irrigation mechanization technology during the off-season and rainfall shortage (Belete et al., 2014).

Forests are one of the prominent natural resources of Ethiopia. It generated economic benefits equivalent to 6.77% of GDP in 2012-13 (UN-REDD, 2014). The country has approximately 26.80 million ha of suitable land for new commercial forests and 190,000 ha of state-owned

plantations in different regions available for development or improved management (EFCCC, 2020). Currently 15.5% of land is covered with forest to provide an economic and ecological support system in the mountainous and climatically precarious country. The country intends to undertake large-scale afforestation and reforestation by the Green Legacy National Program to increase total forest cover to 30% by 2030, besides protecting the existing 17.35 million hectares of forest. Even though such programs and forest potentials are observed, state- and privately owned commercial forest production remains unmechanized except for timber production. Hence, forest planting, cutting, debarking, transporting, pruning, forest fire, forest surveillance, and other operations require special mechanization technologies.

3.4. Major Farming systems in Ethiopia

A farming system can be defined as a group of individual farm configurations that broadly contain a similar resource base, enterprise patterns, household livelihoods, and constraints. Hence, similar development strategies and interventions would be appropriate to enhance their growth potential (Dixon et al. 2001). In the other way round, it is a complex, interrelated matrix of soil, plants, animals, implements, power, labor, capital, and other inputs controlled in part by farming families and influenced to varying degrees by political, economic, institutional, and social forces that operate at many levels.

In the Ethiopian context, the classification of farming systems is based on the available natural resource and the dominant pattern of farm activities

and household livelihoods (Amede et al., 2017). The agroecology that determines the suitability of different crops and pastures based on rainfall and temperature that influence the length of growing seasons, infrastructure, and markets in farming systems dynamics played a critical role in the classification, which we have used as a resource document for the strategy development.

Based on a current study (Amede et al., 2017), the farming systems of Ethiopia are as follows: agropastoral system; arid pastoral and oasis system; eastern highland maize mixed system; highland barley livestock mixed system; highland perennial system; highland sorghum chat mixed system; highland teff mixed system; highland wheat livestock mixed system; lake fish-based system; livestock maize mixed system; lowland maize mixed system; lowland sesame mixed system; pastoral system; Rift Valley fish-based system; sorghum mixed system; and western highland maize mixed system. Even though the study didn't consider high land inset mixed (barely, fruits, and vegetables) farming systems, the classification indicated the most relevant farming systems. The second farming, which is based on traditional agroecology (climatic), is as follows: Tropics warm/arid; Tropics warm/semiarid; Tropics warm/subhumid; Tropics warm/humid; Tropics cool/arid; Tropics cool/semiarid; Tropics cool/subhumid; and Tropics cool/humid. Such intensive classification of farming systems based on current scenarios and agroecology enables the identification and mapping of types of mechanization technology to be used and promoted and provokes a farming-specific mechanization extension system.

Land holding: Farms are generally categorized as smallholder "peasant" farms and large commercial farms. However, in the current situation, categories of farms can be small holders, medium holders, and large holders' farms. Wineman et al. (2021) assert that farm sizes of 0 to 5 ha, 5 to 100 ha, and above 100 ha are categorized as small, medium, and large holders' farms in Sub-Saharan Africa. It's remembered that in the former NAMS (2014), landholding was categorized as follows: 0 to 2 ha small farmers, 2 to 5 ha medium farmers, and above 10 ha holders are categorized as large holder where small holders are the most prevalent type in Ethiopia. However, according to CSS (2022) Agricultural Sample Survey and MoA NRLAIS database, number of agricultural holders by land size are as follows: 2.8 million households (18.3%) have less than 0.1ha, 7.4 million households (32.3%) have 0.1 to 0.5 ha, 4.8 million (21.14%) have 0.51 to 1ha, 4.3 million (18.63%) have 1.01 to 2 ha, 2 million (8.8%) have 2.01 to 5 ha, 166,342 (0.72%) have 5.01 to 10 ha and 25,286 (0.1%) have >10 ha. This shows, 90.37% of households have less than 2 hectares of lands. Hence, appropriate scale mechanization technologies accessibility and usage should be prevalent for most farmers.

3.4.1. Crop production systems

Crops are grown in all sixteen farming systems in Ethiopia except for the pastoral, the lake fish systems, and the Rift Valley Lake fish-based systems. According to FAO (2019), to be able to feed all people and the livestock by 2050, Ethiopia is required to increase its arable land by 9%, increase its cropping intensity by 14%, and increase its crop yields

by 77%. According to this study, the country must bring a tremendous change of operation in its farming system to feed the population and its livestock, which require consuming crops and their residue for feed production.

About the remaining pulses, root crops Fruit and oil seeds we must introduce and promote appropriate-scale technologies addressing the small and commercial farmers to sustain our supply to the local industries and for the export market with value-added products. Horticultural crops are important crops and have second place in production next to cereals. In 2023 the total area covered under horticultural crops (vegetables, fruits, root crops, and others) was 1,175,000 hectares, and a total of 368,000,000 Qt was harvested (MoA, 2023). Most of the time these crops had been produced by traditional ways of production without introducing mechanization technologies. Among horticultural crops, tubers, especially cassava and potatoes, are produced in many areas of the country. Cassava production, mostly practiced in the southern part of the country, is a staple food and source of energy for millions of people and is cultivated in more than 195,055 ha with an average yield of 25 tons/ha; it could be potentially expanded to similar agro-ecological zones (Atelaw, 2022). It is one of the major food security crops that creates incomes and livelihoods for farmers, processors, and marketers in the cassava sub-sector. Even though cassava is accounted for in the root crops, a special emphasis is given to treating it separately and addressing the millions of people who depend on the crop as a food security and a means of livelihood in the south and southwestern parts of the country.

Through the introduction of appropriate-scale mechanization technologies, the smallholder cassava farmers will be encouraged to work in cassava clusters, using semi- and mechanized technologies, and with proper management, to increase the average yield/ha from 50-80 ha, and process their produce in small-scale industries organized by the cassava producers' cooperative or organized youth. With this venture, cassava production capacity will increase, post-harvest loss will be reduced, job opportunities will be created, and the livelihood of the cassava-producing community will be improved, resulting in the highest contribution to the country's GDP.

Since these horticultural crops are not supported by mechanization technologies, the total postharvest loss of horticultural crops, including fruits and vegetables, at various stages—harvesting, storage, transportation, and marketing—ranges from 15 to 70%. Postharvest loss of vegetables alone is about 40%. Fruits like mango, banana, papaya, avocado, sweet orange, etc., take the largest share of the total postharvest loss. The major postharvest losses are caused by mechanical damage, premature harvesting, harvesting, packaging and storage techniques, and transportation, as well as cooling and cold storage facilities, to keep the quality and increase the shelf life of the produce.

Most of the horticultural production activity (seeding, planting, harvesting) is conducted manually by hand tools, which is laborious and time-consuming; drying and packing facilities are seldom organized; and the unavailability of special transporting and delivery vehicles from the

field to the market sites is exacerbating the deterioration of the quality of the produce and increasing its perishability, resulting in price reduction or total loss. To increase the production and productivity, minimize post-harvest loss, increase the quality of the produce, and secure the local and international market, employing the enabler "agricultural mechanization" in planting, management, harvesting, packing, and small-scale processing should be applied to benefit the players and contribute to the country's GDP.

3.4.2. Irrigation system and irrigated agriculture

Ethiopia has twelve river basins with an annual flow of 124.5 billion m^3, an estimated groundwater potential of 6.5 billion m^3 (Awulachew and Ayana, 2011), and an estimated irrigation potential that varies from 3.5 to 11 million hectares. The present irrigation facility in the country is not sufficient. The country's potential, as indicated, is immense, out of which at present, using traditional and modern irrigation systems, 10-12% of the total irrigable potential, or only 1.5 million ha, is net irrigated.

In order to bring out more area under irrigation, it is necessary to introduce new techniques of irrigation like drip and sprinkler irrigation and, at the same time, optimize fertilizer through the drip system by applying liquid fertilizer, which can reduce the amount of usage by half. Under various experiments conducted, based on the performance of the system, crop yield on average increases from 70% to 90%, whereas considerable water savings ranging on average from 50% to 70% is registered.

3.4.3. Livestock production system

With a rapidly growing population, increasing urbanization, and rising incomes, domestic demand for meat, milk, and eggs is expected to increase significantly in the foreseeable future. The livestock sector can also be a major contributor to poverty reduction by improving the livelihoods of rural people. Approximately 85% of Ethiopia's population is rural-based, and livestock supports the livelihoods of about 80% of rural people (ILRI, 2011). However, the income of 30% of the rural population is below the poverty line (MoFED, 2013).

Dairy farm mechanization system: The four major dairy production systems are commercial, urban, and peri-urban, mixed crop livestock, pastoral, and agro-pastoral systems (FAO, 2019). Milk produced in milk shed areas of the peri-urban and rural areas of the mixed and pastoral farming systems of the country could be the major share for the struggling urban milk market by introducing proper mechanization intervention by equipping collection centers or dairy cooperatives. The milk produced by individual farms is collected and brought to the nearby milk collection centers (cooperative, private, or nearby milk processing plant) equipped with dairy mechanization technologies located mostly within a radius of 80 km. During collection, milk is sampled for quality, tested, and the amount measured, and then due payment is made to the milk producers. The delivered milk in bulk is transported in milking cans or in large-sized milk tankers without due attention to refrigerated transportation systems to the commercial dairy system or small-scale dairy processing in peri-urban centers. To maintain milk quality and minimize wastage/

losses and secure additional income to support the rural family, to create job opportunities in the rural centers and sustain the supply of milk to the processing plants, this sector should be supported with appropriate milk handling and transportation mechanization technology.

Sheep and goat production system: The system is mainly practiced in mixed crop and livestock, in agro-pastoral, in specialized ranches, and in urban and peri-urban production systems. These small ruminants are mainly kept by the smallholder farmers and are major sources of nutrition and income. If there is a mechanization intervention like a proper shed or a means of transportation to the market, the subsector's contribution will grow and play a major role in the country's economy.

Camel production system: Camels are kept predominantly in pastoral and agro-pastoral areas of the country; few are found in the mixed crop-livestock system. The major cattle-keeping societies are the Afar, Somali, and Oromo (Karayu, Gabra, Boren, and Guji). The milking frequency of the camel is 2 to 5 times, and the lactation period is about one year.

With an estimated 7 million camels, Ethiopia has one of the largest camel populations of all countries. The camel population in Ethiopia has grown rapidly in the last few decades, at a rate of 4.5% per year, and this growth is the second fastest of all livestock species in Ethiopia after goats (GBDA, 2024). Facts about Ethiopia's camels and their crucial but underappreciated role in supporting livelihoods and food security in the face of climate change are not properly tapped. If we support

our camels' management through mechanization like milking cans and equipment and conservation and processing technologies, this highly nutritious camel milk, with a milking intensity of 4 to 5 times a day, will be of paramount economic and social importance to the pastoral society of the country.

Poultry farm mechanization system: The poultry production systems are classified as traditional family poultry production, improved family poultry systems, and specialized poultry production. The specialized or commercial poultry industry (the large-35, the medium-37, and the small-157) of Ethiopia is yet to develop to satisfy the ever-increasing demand for poultry and poultry products. The small-scale poultry farmers who keep from 100 to 1000 birds have a significant role to play if supported financially and technologically to expand their business.

The higher ambitions of setting targets are not enough without a concrete step to move from the traditional scavenging family poultry to an improved family poultry system. The bulk (the traditional family poultry), i.e., 92%, is the smallholder family, who on average keep 10-20 birds and need technological support to improve and increase their productivity and assure their own nutrition security and at the same time economically augment their family and play a role in the country's economic development.

Bee farm mechanization system: The country is first in Africa and ninth in the world, having 7 million honeybee colonies (CSA, 2021).

The national production of honey and beeswax amounts to 50,800 tons and 500,000 tons, respectively. A total of 5.92 million local and modern beehives are found in 1.4 million households; however, the amount of honey processed accounts for only 10% of the actual potential (Gratzer et al., 2021). Ethiopia has the largest colony of bees in Africa, but the products (honey and propolis) are poorly managed and processed to play a significant role in the country's economy through job creation and foreign exchange earnings, as this is a powerful way of tackling poverty at a grassroots level.

Fisheries production system: In the country's lake, river, and dam fishery production system, there are over 200 known fish species, of which 194 are native, 40 are endemic, and 11 are exotic. Tapping of the resource potential is very insignificant compared to the potential it has currently and in the coming years due to the catchment of the Renaissance hydroelectric dam with an area of 172,250 km², which is equal to the total area of 10 lakes found in the country.

Ethiopia's fish production has increased by a factor of 5 in the past three decades (3500 tons in 1983, 15,681 in 2000, and 18,058 in 2010, respectively); however, fish produced in the reservoirs is too low (8,059 t/year). The current fish harvests in the reservoir are significantly below the predicted potential yield, accounting for only 35% of the calculated fish production capacity (Anteneh et al., 2023). With the recently organized few youth groups and around 70 newly created artificial Islands at GERD, with their venture, the harvested amount in less than

a year's time equals 66% of the total harvested fish from 10 reservoirs around the country.

For Ethiopia to release its potential in the fishery subsector, there should be government policy as well as technical support to reduce post-harvest fish losses during storage and transportation and resolve the infrastructure issue, like the road from the fishing ground to the city or processing center, and improve the absence as well as fluctuation of electric power, apply mandatory measures to the use of proper and standardized fishing equipment, and widely introduce motorboats equipped with navigation and resonance apparatus and systems.

Feed processing mechanization: Ethiopia is endowed with ample and suitable land for forage and hay production, especially in the areas of high livestock population where frequent drought results in the death of thousands of animals due to a lack of appropriate forage and hay development measures to tackle this recurring problem. To alleviate such problems, forage system mechanization is pertinent. Mechanization of forage is not only limited to field operation but extends from the field harvesting through processing and storage. Different mechanization technologies are employed in the field. Transporting and feeding facilities requires machinery, which keeps longer without losing the nutritional value of the forage and maintains moisture content during the preservation process.

Establishment of small, medium, and large-scale feed processing plants by the private sector, specialized farmers, and cooperatives is required

with seed money support from the government. The Ministry of Agriculture is coming up with the appropriate design and identification of machinery, installation, and commissioning of the setup to support the private sector or cooperative as a feasible strategy to avail concentrate feed for livestock to enhance their production and productivity.

3.5. Institutional framework for agricultural mechanization development

3.5.1. Agricultural mechanization structure

Currently agricultural mechanization structures from federal to regional and zonal are not consistent. Some regions have organized structure but lack professional pertinence to mechanization; some don't have such structure and institutional arrangement. Lack of institutional capacity of regions and zones, inadequate manpower in structure, and non-professional and unskilled staff have increased the challenges in effectively planning and executing agriculture mechanization programs and initiatives that would contribute to the achievement of desired results. Besides inadequate planning, scheduling, monitoring, evaluation, and regulation of agriculture mechanization programs and activities have hindered the development outcomes in the agricultural sectors.

3.5.2. Agricultural mechanization Extension service

In Ethiopia, agricultural extension offers technical guidance, provides information, transfers new technology, and helps farmers determine their problems to overcome agriculture-related constraints by persuading them to adopt/adapt and use innovations. Hence, it plays a crucial role

in agricultural development and rural transformation (Leta *et al., 2017;* MoA, 2017). Farmers are expected to change behavior on technology adoption and usage and thereby develop interest in technology.

Agricultural extension agents, formally known as Development Agents (DAs) in Ethiopia, are involved in multiple activities of agriculture and rural development. They provide general advisory services in crop, livestock, and natural resource management at the kebele level (Abate, 2008). However, none of the DA's members provide advisory services in crop and livestock mechanization altogether. Even the existing government structure, from federal to regional all the way down to the woreda, has no agricultural mechanization extension. But the government of Ethiopia is highly committed to sustainably increasing agricultural production to meet the growing demand for food, industrial raw materials, and foreign currency earnings (MoA, 2017). This couldn't be possible without the involvement of agricultural mechanization extension services at all levels.

3.5.3. Mechanization research and technology development

The main objective of Agricultural Research Centers (ARC) is conducting research that will provide market-competitive agricultural technologies that contribute to increased agricultural productivity and nutrition quality, sustainable food security, economic development, and conservation of the integrity of natural resources and the environment. Moreover, agricultural engineering research centers can innovate in the design and fabrication of affordable, efficient farming machinery tailored

to the needs of smallholder farmers. This reduces labor intensity and improves productivity. The center can also develop advanced storage and processing solutions to reduce post-harvest losses, ensuring that more produce reaches the market in good condition.

Bearing missions in mind, the following national and regional agricultural engineering research centers have been established. These are the Asella, Bako, and Jimma Agricultural Engineering Research Centers and Fedis Agricultural Engineering Research at the process level in Oromia; the Mekele Agricultural Engineering Research Center in Tigray; the Somali Agricultural Engineering department; the Wolayita Rural Technology Promotion Center; the Afar Agricultural Research Center; and Melkasa, Kulumsa, and Fogera, which are at federal agricultural research centers. At the federal level, Kulumsa is working on training of operators and technology demonstration, whereas Melkasa and Fogera are working on technology generation, testing, and demonstration.
At the regional level, like that of the federal ARC, Bako, Assela, Fedis, and Mekele are working on technology generation and evaluation.

Agricultural Engineering Research centers were established with the mandate of carrying out research in agricultural mechanization technologies and innovations geared at enhancing productivity and value addition for crops and livestock in Ethiopia. However, its performance has been hampered by limited research fund and technical capacities in human resource and infrastructure. The centers have been focusing on technology adoption, modification, and generation while technology

multiplication and dissemination (for the purpose of pre-extension) is undermined by the centers. Besides, technology generation by itself had been relied on for crop association, neglecting livestock parts.

3.5.4. Training and capacity building programs

Agricultural mechanization sectors' capacity building ensures sustainability, increases resource-use efficiency, and ensures effective execution of activities pertaining to mechanization and its alliance. The department/section arranges capacity-building programs (both updating and upgrading) for its staff. Capacitating staff in both knowledge and skill by providing training enables them to deliver responsibility and support regional mechanization sectors and their stockholders. For any organization, institution, or even nation to function effectively, there must be human and material resources, of which human resources are the most paramount, since other resources cannot be utilized without human beings. Hence, acquire both physical and intellectual skills, which enable individuals to be self-reliant and useful members of the profession.

Higher learning institutions: Currently, about six Higher Learning Institutes (HLI) offer agricultural engineering/mechanization programs in Ethiopia; in those public universities that offer agricultural engineering and mechanization programs at the first- and second-degree levels, a small number of students are enrolled in these programs. This shows that the demand for agricultural engineering/mechanization is declining at the university level from time to time due to graduate unemployment

in governmental and private agricultural sectors at the federal and regional levels. This resulted in widely low availability of appropriate professionals in the programs. In Ethiopia four universities are teaching BSc. In agricultural engineering, three universities are teaching MSc in agricultural engineering/mechanization.

Table 1. Agricultural Engineering graduates (BSc) from AU, WU, HWU, and HRU from 2012 to 2016 E.C.

No	Organization/ University	2012	2013	2014	2015	2016
1	AU	23	19	32	24	05
2	HWU	34	71	68	34	09
3	HRU	64	36	27	18	06
4	WU	31	19	23	04	04

Table 2. Agricultural Engineering graduates (MSc) from HRU, BDU, and ASTU a from 2012 to 2016 E.C.

No	Organization/ University	2012	2013	2014	2015	2016
1	HRU	05	03	04	08	09
2	ASTU	07	04	07	11	03
3	BDU	-	-	-	05	02

ATVET colleges: Level-based trainings in farm machinery operation and maintenance at selected ATVET colleges based on the Ethiopian Occupational Standard (EOS) prepared in 2018 by MoA & the national ATVET agency. Agricultural TVET often needs specialized training centers, having adequate land to conduct practical field demonstrations

Because many centers have access to the latest agricultural equipment and machinery, which is necessary to provide meaningful demonstrations and practical classes. Three ATVET colleges, namely Wukero, Wereta, and Alage, were identified to start the training program. However, only Alage and Ardayita ATVET colleges started to give the training. Alage ATVET College is providing a level-based training program on farm machinery operation and maintenance. The college is fairly equipped with machinery & workshop equipment such as power tillers, tractors with implements & combine harvesters, which are available in the college for training. It has about 15 trainers; three of them have MSc degrees, and 12 are BSc holders with agricultural engineering professions. So far about 395 trainees (of which 84 are female) operators and maintenance technicians have graduated from this college since 2011-2015 EC.

Ardaita ATVET College recently started to provide level-based training in agricultural machinery and equipment operation and agricultural machinery and equipment maintenance, which takes 2-3 years of training duration. The curriculum was prepared as per the standard of the TVET program. Currently, the college is also working on curriculum development for business-related courses. Preparation in terms of allocating tractors for trainees and workshops with facilities. There are about four tractors, and one new tractor is expected for short-term training that can be used for training. Currently the college has admitted students from regions and is giving training, and there is good support to strengthen the program from the government, like MOA and MOLS. Bure ATVET is one of the colleges in the Amhara region giving level-

based training on crop production, irrigation, and natural resource management. This college has a plan to give training on agricultural mechanization operation & maintenance soon. There are three trainers with qualifications of MSc and BSc, including operators. Machinery such as tractors and combines is available at the center that can be used for training.

Table 3. ATVET graduates by agricultural machinery maintenance and operation

No	Region	Number of graduates
1	Oromia	28
2	Amhara	2
3	SWE	14
4	CE	2
5	Gambela	8
6	Beneshangul Gumuz	12
7	SE	14
Total		**80**

Public and private short-term training centers: In Ethiopia, tractor operation and driving, which takes two to three months, has been started by the Ethiopian Roads Authority at the Alemgena Training Center, primarily established to train construction machinery operators at the national level. This center was the only training center established to provide training and licensing for machine operators by using a customized curriculum and with limited capacity and facilities required for agricultural machinery operation. In addition, there are few regional institutions, such as the Amhara region waterworks

enterprises, primarily established to train construction machinery operators. The government institution trains and licenses machine operators, which takes two to three months at the regional level.

Kulumsa Agricultural Training Center was also established by the effort of MoA and GIZ to offer tailor-made short training courses mainly for tractor operators and experts engaged in agricultural mechanization. After 2019, the offer of short-term courses declined, and they started to provide longer-duration accredited training courses on the operation of tractors and combine harvesters that enable participants to receive a driving license. So far about 395 trainees (of which 84 are female) operators have graduated from this center.

Ethiopian Agricultural Business Corporation was established as a federal public enterprise in 2015 by merging five different public enterprises. Agricultural Mechanization Service Enterprise (AMSE) was established with a training unit that provides short-term training courses for tractor operators, mechanics, electricians, and welders as one function. It has a well-designed workshop and training facility with classrooms and offices. The workshop and training center are well constructed and equipped with teaching aids & materials of Russian design, even if currently outdated. Currently the corporation has changed its business model to import & sell machinery and other agricultural inputs such as chemicals, fertilizers, etc. The training program is abandoned with all the training facilities unused; there is a big potential to use the facilities for the needed training programs

on agricultural machinery and equipment operation & maintenance in the future.

Agricultural machinery suppliers also provide training to operators mainly to familiarize existing operators with their product. They have no regular training program, and the training type they offer is product specific and does not follow standard training modules. Similarly, private training institutes like Kaleb Farmers House Training Center and GS Operators Training Center also got accreditation from the Road Transport Authority (RTA) to provide similar types of training in tractor and combine harvester operation. The GS operators training center, based in Adama, is giving tractor operation, combine operation, and loader digger and excavator operation training. The training materials (for short-term courses) are developed based on the competencies specified by the road transport authority. So far about 1650 graduates, 674 in tractor operation and 921 in combine harvester operation, have graduated from this center.

Kaleb Farmer's House-Training Center, based in Shashemene, is giving training on both tractor and combine harvester operation on a short-term basis. So far about 1300 have graduated in both tractor and combine operation competencies. There is a plan to give short-term training in the future, but they have not yet started on preventive maintenance and hydraulics competencies. The machinery maintenance knowledge and skill upgrading training centers are nonexistent except for informal trainings given by the suppliers as part of after-sales services and public institutions and NGOs working in the sector.

In general, as the demand is constantly growing, there is a big gap between the number of skilled operators & mechanics on duty and needed by the sector. In many of the region's tractors and other machinery were found non-functional before the service life due to operators' faulty operation and use. As these institutions are very few in number and limited in capacity, they cannot satisfy the needs of the market. Thus, to fill the huge demand gap for skilled agricultural mechanics and operators with the required number and quality, it is imperative to strengthen existing level-based & short-term training programs on the operation and maintenance of machines.

3.5.5. Agricultural machinery testing and certification

Farm machines supplied to the farmers must ensure functional and life reliability. For this, a testing and certification center is inevitable for our nation for testing of imported and locally manufactured machines according to a well-established standardization procedure. This helps to ensure the quality of machines reaching the farmer/farming community and pinpoint the improvement needed for higher efficiencies/enhanced quality for the manufacturer. All new and adapted agricultural technologies should undergo standards and testing processes to ensure consistency and quality control. In particular, standards and testing processes should:

- Ensure operational safety
- Ensure the suitability of machines to a country's conditions
- Educate customers on the comparative performance of various machines
- Provide input to researchers on improvement of quality
- Serve as a basis for standard specification for manufacturers

However, imported and locally manufactured agricultural machinery has a quality problem, and there is no testing center to evaluate and approve their quality at the national level. Based on these facts and the recommendation of the former strategy, the National Agricultural Machinery Testing and Certification Center is under construction. It is expected that the center shall be fully equipped with all international test standard facilities to conduct the commercial and confidential tests.

3.5.6. Financial institutions and access to finance for mechanization

To enable access for farmers' contractors to appropriate mechanization technology and mechanization services, a resilient and efficient financial institutional system needs to be in place (EAMS, 2014). The government has facilitated financial access in the past half a decade for small and medium farm-holders and organized youth groups to own agricultural machinery by the 30/70 financial model. i.e., farmers/organized groups can save 30% of the total price of the machinery, while 70% of the total price is provided by the financial institutions (banks like the Commercial Bank of Ethiopia, Cooperative Bank of Oromia, Bank of Abyssinia, Sinqe Bank, Awash Bank, Tseday Bank, etc.) holding the farmer's land certificate on a collateral basis and the machinery ownership book as a guarantee. The loan is being provided for three to five years based on individual bank policy for agriculture. This financial access is limited to imported machinery and isn't applicable for locally manufactured small-scale technologies.

Services vary from bank to bank. Great variations in bank interest rate (7 to 18%) and service charges (from none to 30,000) were reported.

Tedious and tiresome bureaucratic chains from woreda to regional and bank to facilitate the process make the farmers bored. Above all, on-and-off bank loan/credit provision and lack of interest to provide loans for farmers and organized youth groups are among the critical bottlenecks. Another mechanization finance arrangement is the provision of lease financing for machinery leasing. The program started eight years ago through the Development Bank of Ethiopia (DBE). So far 450 leases have received 450 tractors and 48 combine harvesters through the agricultural machinery leasing program.

Many developing countries, like Nigeria, Ghana, India, South Africa, Egypt, Libya, Algeria, Namibia, etc., have agricultural banks to support the agricultural sector permanently. But in Ethiopia none of the banks are agricultural banks. However, to overcome financial-related problems, Ethiopia should establish an agricultural bank and expand the machinery leasing program by participating with other banks to allocate adequate finance for mechanization technologies.

3.5.7. Agricultural mechanization services provision

Currently mechanization (hire/rental) services are provided by private service providers, cooperative unions, organized youth groups, and in some places, by the Agricultural Works Corporation, which is a government organization. Private service providers have an organized and registered 'Private Service Providers Association,' mainly operating in the Oromia region. Service providers are mainly engaged in the provision of harvesting and threshing services using combine harvesters.

They primarily serve wheat-producing areas of Arsi-Bale and sometimes engage in migratory harvesting service provision, going as far as Amhara, the southern states, Afar, and the Ethiopian Somali region.

Besides, some Farmers Cooperative Unions (FCU) organized in Amhara, Oromia, and Southern states, mainly owning tractors and combine harvesters, are providing services to their fellow members. Youth groups organized into 28 associations owning 80 power tillers and 4 types of accessories as well as trailers are currently providing rental services to the smallholder farmers in the Amhara, Oromia, and southern regions.

Service provision systems in cooperative unions lack dedicated structures, skills like business development and appropriate business models, as well as operation and maintenance. The same gaps are also observed in organized youth groups. The service provision by the agricultural works corporation has a limited operation area, and the services are not also diversified, and it lacks motivation to utilize its underperforming infrastructure for maintenance and its training center for operators and maintenance technicians.

In such services, organized youths (who have graduated from academic institutions) and farmers' young families are organized in groups of a minimum of three and purchase machinery from dealers/suppliers with a 20-30% down payment of the total price of the machine. Those who have enough finance can purchase with 100% payment. Since organized youth groups may face a shortage of finance, based on the government

loan facility model, they are expected to deposit a down payment to the chosen financial institution\/bank, which is supposed to provide a loan for the remaining payment. Finally, they owe machinery if the machinery ownership certificate is being held by a financial institution as collateral until they clear the loan.

These youth are said to be entrepreneurial service providers. Based on their ultimate activities/operation and machine type, they move from one region to another region to give mechanization services like land preparation, harvesting, threshing, and shelling services. This model is less productive in area coverage since the capacity of the machine they have is less as compared to private farmers. They typically operate within a small radius of their vicinity and offer mechanization services mostly to small-scale farmers, but also commonly to medium-scale farmers. In addition to the public enterprise, there are also private companies importing agricultural machinery (combine harvesters, large and small tractors, farm implements, etc.) and providing rental services to smallholder farmers, mostly in the wheat-based Arsi and Bale highlands.

3.5.8. Agricultural machinery manufacturing, import and aftersales services

In Ethiopia, the agricultural machinery manufacturing sector in Ethiopia remains significantly underdeveloped, presenting a major obstacle to advancing mechanization. While there are some machinery import dealers and local manufacturers, most of the machinery is imported, with

over 33 machinery suppliers operating in the country. Currently there are different private agricultural machinery dealers/suppliers. Some of them are Kegna Agricultural Machinery Company, Woreta International, MOENCO, Ries Engineering, AMIO Engineering, Hagbes, Adeb Engineering, Gadeb Engineering, Adama Agricultural Machinery Industry, Kaleb Farmers House, ALT, Amhara Metal Corporation, Ethiopia Agricultural Works Corporation, Jebdu Motors, etc. However, only a small number of machinery companies are engaged in both import and manufacturing. This creates a reliance on foreign machinery, which increases costs and limits accessibility for smallholder farmers. The local manufacturing sector struggles with outdated technologies, limited skilled labor, and inadequate support systems. The limited production capacity, reliance on outdated technologies, and shortages of skilled labor are key barriers preventing the sector from meeting the growing demand for agricultural machinery. Currently, most machinery is imported, with only a few firms engaging in both manufacturing and assembly, leaving the sector unable to cater to the specific needs of smallholder farmers. This dependence on imported machinery increases costs, reduces affordability, and limits accessibility, particularly for rural farmers with constrained financial resources. Furthermore, the lack of local manufacturing results in challenges such as delays in acquiring spare parts, prolonged machinery downtime, and higher maintenance costs, all of which discourage mechanization adoption.

Despite the situation, efforts to support agricultural machinery manufacturing include tax waivers for importing agricultural machinery

and parts to encourage local assembly and production. Yet this initiative still mostly focuses on direct machinery importing by private and state-owned business sectors instead of focusing on technology transfer and collaboration with international brands for local manufacturing and research in the country context and use of local resources such as human skill and available raw materials. Additionally, initiatives such as capacity-building programs for manufacturers and the promotion of innovative mechanization ideas are being implemented to enhance local production capabilities. However, significant gaps remain in infrastructure, technology transfer, and financial support, all of which are critical for fostering a robust local machinery manufacturing sector. In addition, most of the initiatives were focused in the central areas rather than reaching out to the remote parts of the country.

This situation creates a ripple effect on mechanization development. Without a robust local machinery manufacturing base, the country potentially will be unable to provide affordable and appropriate mechanization solutions to farmers and as a whole for mechanization development. This stifles agricultural productivity, reduces efficiency, and limits the sector's ability to modernize. Addressing these issues by enhancing local manufacturing capacity through technology transfer, developing dealer standards, skill development, and financial incentives is critical for improving mechanization access and fostering sustainable agricultural growth.

3.5.9. Rural Infrastructure

Rural infrastructure is vital for sustainable agricultural mechanization and rural development. Rural infrastructural development is an essential prerequisite for development of the agricultural sector (FAO, 2013). Apparently, mechanization technology, off-road mobility, after-sales services (repair and maintenance) at the farm level, access to energy near the farm site, communication to get machinery services, etc. can be insured with the development of rural infrastructure. Hence, serious attention should be given to the following rural infrastructure as one of the cross-cutting issues for strategic mechanization and rural development.

Rural access road: Rural roads have a positive impact on rural inhabitants by enhancing their ability to access social services, transporting agricultural products to nearby markets, improving the living standards of farming communities, shortening the time elapsed to travel to the main road, and creating jobs for youths. Apparently, rural access roads are a backbone for off-farm mobility of farm machinery, especially for self-propelled machines such as two- and four-wheeled tractors, combine harvesters, threshers, trailers, etc. To increase the productive work of tractors and other machinery, a cross-sectoral interconnecting with the Ministry of Transport and Logistics, which works on rural road infrastructure construction and maintenance, is crucial.

The development of rural road infrastructure has been shown to promote economic growth and reduce rural poverty. Similarly, a well-developed road transport sector in developing countries like Ethiopia is expected

to fuel the growth and development endeavors of a nation. Besides, rural road transport facilities are essential for expanding education, health service provision, trade facilitation, and agricultural technology mobilization. According to UNECA (2016), expending large investments on infrastructure development in Ethiopia is the key to rapid and uninterrupted economic growth, which registered more than double the infrastructure development between the years of 2009 and 2013, putting the country on top of the continent.

Ethiopia has shown strong commitment to the road sector. The country had 26,550 kilometers of road network in 1997 and increased by 470% to 125,000 kilometers in 2016 by launching the Road Sector Development Program (Frew, 2018). This commitment has also seen the expansion of the rural network and the initiation of the Universal Rural Road Access Program (URRAP) in 2011 to provide all-weather road access to all kebeles in a few years. The success of this strategy program has increased rural access roads from 13% in 1997 to 39% in 2014/15 by constructing 71,500 kilometers of road (ERA, 2016). During this program, many rural kebeles were interlinked with each other. Farmers tried to get market access to their produce. Agricultural technology mobility has increased at a time. In general, the URRAP brought a significant impact on the livelihood of the rural community. However, the program didn't reach all kebeles at a time; it didn't last longer for an unknown reason. Most of the roads are out of function due to lack of maintenance. Especially during the summer rain season, the roads never entertained transportation of any kind, including farm machinery, due to mud formation.

Fuel and energy system: If we want to get enough energy from agriculture, we must take energy to agriculture in the required amount. Fuel storage tanks or stations ensure a readily available fuel supply right on the farm premises. This eliminates the need for frequent trips to refuel off-site, saving time and increasing operational efficiency, eliminating long queues waiting for fuel, and reducing operational disruptions. Farmers can conveniently access fuel whenever required, optimizing productivity, and minimizing downtime. However, in the existing situation in Ethiopia, agricultural machinery owners and mechanization service providers had been facing the following challenges.

- Shortage of fuel at fuel station. The fuel station stands mostly empty.
- Long queue waiting for filling fuel
- Long-distance driving from farm area searching for fuel
- Abruptly increasing of fuel price
- Lack of special subsidy of fuel for farm machinery

Rural electrification: Electricity is very critical for farm work in villages and farming areas. Our country has a potential and an opportunity to support its agriculture by means of electric power, which increases the farm power index of the country by diversifying electric power use in the area, such as irrigation systems, drainage of surface and underground water, farm fencing, threshing, and milling of crops, seed cleaning and running grain driers, and mechanization of dairy development like milking, pasteurizing, bottling, and canning. In addition, agricultural machinery battery charging, tire inflating, repair, and welding of broken components, rebuilding and reconditioning machines, modifying, and machining, etc. required electric power in rural areas.

In poultry farming, for testing eggs and hatching and keeping optimum temperature for the bird's development and productivity; development and expansion of rural small-scale processing like oil extraction, rice milling, and grain grinding; running facilities for fruit and fish preservation and building cold storage; and the overall increase of productive efficiency of every individual using power-operated machines. Improving the farmer's standard of living in the farmhouse by providing water, light, and other domestic comforts. Onyeji et al. (2012) stated that electrification in some rural communities is considered as a driver of sustainable and economic development.

In Ethiopia more than 80% of the population dwell in rural areas. Almost all agricultural products come from rural communities. However, there is a great electric infrastructure shortage in our country to operate the above-listed agriculture-related facilities. Rural communities have remained marginalized from electric access. According to the Sustainable Energy for All (SE4ALL) initiative, there are about 789 million people who do not have access to electricity, and about 72% of these people are in the rural areas of Sub-Saharan Africa (Andom and Amuwuakwa, 2016). Ethiopia has one of the lowest electrification rates in Sub-Saharan Africa, with under 20 percent of the nation's towns and villages electrified. Access to electricity is about 16%; most of these customers consume less than 50 kWh. Almost 60 million Ethiopians were still not connected to the main grid or any other kind of isolated generator (World Bank 2022, a, b, & c).

Rural access to water: it is very important both for drinking of animals and humans and watering of crop ecosystems. Drinking water

requirements increase at a higher temperature and low humidity. Depending on the season, cattle must be watered at least every second day at a rate of 10 to 40 liters/head, and camels must consume 100 to 150 liters/head at a time every five to six or even 8 days. Against the requirements, however, animals in the lowland drink every four days, and perhaps insufficiently. So, the impact of under-watering results in poor animal health and under-productivity. When seen from the large livestock population of the country, the demand for drinking water is substantial (Sileshi, 2008).

Results of our assessment also indicated that very few commercial farms and feedlots have their sources from deep dug holes and tap water, but most of our smallholders get them from traditional boreholes, rivers, or ponds and are located very far away and may take days to reach and access. This state of the water source is affecting the productivity and health of our livestock and human population. Provision of safe, accessible, and reliable water is very critical (Zemikael et al., 2022). As water is critical for livestock development and feed production, it needs a rural mechanization intervention with a government policy and technical support. With private sector participation/involvement, water can be availed with tractor-mounted and PTO-operated drilling/rigging machines.

During 2016, 4% have safely managed services, 30% have basic services, and 26% have limited water services in rural areas of Ethiopia. About 40% of the country's rural population had unimproved water services. According to Ministry of Water, Irrigation and Electricity (MoWIE)

estimates, rural water supply coverage reached 63% by mid-2016 (MWAE, 2019; WASH, 2017; CSA 2016; and ICE 2017). To increase production and productivity of agriculture through mechanization, maintaining productivity in society must be done by improving life quality and health conditions. This could be possible when we make a great difference in systematically improving rural water supply systems.

3.6. Policy Environment for mechanization development

3.6.1. FDRE Agricultural and Rural Development Policy (ARDP)

The Agricultural and Rural Development Policy (ARDP) revised by 2024 underlines the importance of mechanization for its contribution to agriculture and rural development. It gave emphasis on full-scale coverage of agricultural mechanization services of preharvest, harvest, post-harvest, and processing of crops and livestock value chain. Its contribution to increasing productivity of labor, land, and associated production elements, thereby decreasing pre- and post-harvest losses, is highlighted. It also stresses that application of mechanization technology will increase production quality and value addition. To increase technology supply and expand mechanization services and access to farmers in the country, the government exempted duty and tax on agricultural technologies. Therefore, the policy addresses the following direction to alleviate problems:

1. Create conducive environment for locally manufacturing, multiplying, and imported mechanization technologies;
2. Motivating and conducive systems shall be created for private and cooperative unions to play their leading role in

mechanization. Besides, mechanization technology promotion enactment, marketing and after-sales services systems shall be enforced;

3. Prepare technology usage and handling systems; ensure strong quality control and service provision systems; build mechanization supportive infrastructure.

In the major policy direction, inclusiveness, and sustainability of agricultural development among smallholder farmers have been underlined. The policy also stressed the development to be comprehensive and agroecology-oriented. It indicated the development of cold storage availing of safe livestock transportation; forage development and supply; and development and marketing of smallholders' crops and horticulture and livestock, including fishery and poultry. In addition, the need for the development of programs and projects on feed and forage development and agricultural mechanization services and the introduction and establishment of digitalization of agricultural systems were also clearly highlighted. To effectively implement the policy directions, well-organized and aligned mechanization systems and strategy are very important to respond to the policy statements.

3.6.2. Ten-year development plan (2021-2030)

The ten-year National Development Plan (NDP) has addressed agriculture as a sector that received particular attention both on paper and within the broader development narrative, yet the sector is still characterized as the least productive. During the homegrown economic reform (2021-2022) process, there have been significant political commitments from

the government to improve research and development in agriculture. The reform addressed the agricultural sector reform, which aims to improve the role and participation of the private sector, expand small- to large-scale irrigation development, improve the supply of inputs and finance, enhance the productivity of livestock, protect the environment and natural resources, improve agricultural production, reduce post-harvest loss, and promote import substitution of major agricultural crop production.

The main objectives of the agricultural development plan are to raise the incomes and livelihoods of farmers and pastoralists and end poverty by making agriculture more productive and competitive. To attain the above objectives, the plan has addressed the following core functions. These are reducing the reliance on rain-fed agriculture by developing irrigation capacity; expanding agricultural mechanization services; enabling highly productive smallholder farmers to become investors by assisting them to have access to additional land; improving animal husbandry, fodder development, and animal health; expanding horticulture development; expanding the participation of private investors in agriculture; building institutional implementation capacity within the sector; creating job opportunities; and rendering agriculture more resilient to climate change by reducing the impacts of environmental and climatological changes affecting it. Hence, the role of agricultural mechanization to attain crucial objectives is paramount.

3.6.3. The Malabo Declaration

The Declaration at the African summit in Malabo in June 2014 was aimed at *accelerating agricultural growth and transformation for shared prosperity and improved livelihoods.* It reconfirmed that agriculture should remain high on the development agenda of the continent for its economic growth and poverty reduction. Based on vision, our country had been doing a lot, and significant changes had been achieved. To achieve the objective of the Malabo Declaration, the government works to transform the agricultural sector through enhancing agricultural mechanization technology utilization. Hence, agricultural mechanization is one of the crucial technological elements to realize such an impressive agricultural vision.

3.6.4. Sustainable development goal (SDG) of Ethiopia

The 2030 Agenda for Sustainable Development adopted by the United Nations, with SDG1 aiming to eradicate poverty and SDG2 aiming to eradicate hunger, ensure food security, improve nutrition, and promote sustainable agriculture, is adopted by our country, and has identified interventions to meet the targets. Over 110 key interventions have been identified as necessary to meet SDGs targets in Ethiopia. Existing national and sectorial strategies have to some extent already identified 90 of these intervention areas and made some progress in driving their implementation. However, in many cases these interventions should be scaled up significantly to meet the challenging SDG targets. The interventions are in agriculture, irrigation, environment, water, energy, ICT, and gender. Hence, an agricultural mechanization strategy is crucial to attain the goal.

3.6.5. African Union (AU) Agenda 2063

AU Agenda 2063 is focused on the voice and aspiration of Africans to eradicate poverty to be a prosperous continent for inclusive growth through social and economic transformation of the continent by securing sustainable development with a means and resources to drive its own development. This aspiration is also in line with Ethiopia's HGEDP, agricultural innovation, and technology fostering.

3.6.6. Sustainable Agricultural Mechanization in Africa (F-SAMA)

In addition to the national and international developmental goals, at the continental level, the NAMS needs to react to aspirations/ambitions of the AU Agenda 2063, the Malabo, and the CAADP Framework. It must internalize the ten priority elements of the Framework for Sustainable Agricultural Mechanization in Africa (F-SAMA). The F-SAMA provides a mechanism for concerted action on sustainable agricultural mechanization by all key stakeholders on the African continent. The NAMS should give emphasis especially on the 9th and 10th elements of SAMA that focus on the need for a long-term vision policy and strategy issues, which we have concurred with, and creating sustainable institutions for regional cooperation and networking, which we are striving towards by establishing a National Testing and Certification Center.

3.6.7. Vision 2020-2030 Ethiopia

The ten pillars of Ethiopian Vision 2030 are quality economic growth and shared prosperity, economic productivity and competitiveness,

technological capability and digital economy, sustainable development financing, private sector-led economic growth, resilient green economy, institutional transformation, and gender and social inclusion. To attain pillars of as properly as possible, the indispensable role of agricultural mechanization is paramount.

3.6.8. Tax Incentive on Agricultural Mechanization technologies and services

In 2018 the government exempted 555 types of machinery and equipment from duty and import tax during importation. Tax-exempted items include farm machinery and implements, irrigation technologies, livestock (dairy, poultry, apiculture, and fishery) development technology tools and equipment, crop production, handling and management technologies, and veterinary tools and equipment.

Besides, the government also exempted thirteen types of mechanization services from VAT. This includes services such as land development and preparation for irrigating crops; crop handling, management, and spraying services; harvesting; threshing; and product transportation from farm to storage and processing facilities and up to marketing the produce. The tax exemption has been assumed to bring benefits to the smallholder farmers in terms of geographically expanded service delivery areas and types of services, and with that, to ensure widely and easily accessible services with a reduced cost.

The intent of tax exemptions is to facilitate mechanization adoption by reducing financial burdens on smallholder farmers, who are the ultimate

users of these services. It was assumed that these interventions will encourage service providers to expand their services. It also incentivizes all value chain actors, resulting in triggering machinery importers to bring more technologies with a reduced price, thereby increasing access to mechanization.

However, even if it is assumed that the incentive has brought a significant change in the number of farmers using agricultural mechanization technologies or services, the cost of services has been rising. A proper systematic assessment study should be conducted to verify the change that has been brought about by the tax exemption policy. Other important items such as veterinary, clinical, and personal protective equipment should be included in the tax exemption programs.

3.7. Experience of benchmarking countries

Improving the performance of goods and services of agricultural mechanization will trigger enhancement of production and productivity in all sub-sectors of agriculture where mechanization has an influence. The country's agriculture is demanding dramatic changes because of the promising government initiatives activated in the agricultural sector. To keep its momentum and ensure the sustainability of the registered developments, some critical interventions are reviewed below, to be compared with the achievements of those benchmarked countries, and to share the factors that instigated their dramatic changes.

Ethiopia's agricultural mechanization development is dominated by importing medium- to large-HP 4WT tractors and other agricultural

mechanization machinery. Local agricultural mechanization machinery manufacturing capacity is nonexistent, except for a few assembly plants of SKD imported tractors and small and medium-scale enterprises (SMEs) manufacturing threshers and shellers by importing standard parts (bearings, belts, etc.) and diesel engines.

Mechanization hire service delivery is mostly provided by the private sector; the services are limited to plowing and harvesting. Similar services provided by a few cooperatives and one publicly owned entity are also limited in scope (area covered, type of services provided) and are mostly operating in areas dominated by cluster farming, but those smallholder farmers who are working out of cluster areas aren't benefiting from their services. Ethiopia needs to benchmark improved performances by identifying, understanding, and adapting best practices and processes outside the industry and implementing the results.

As digitalization is a pathway to prosperity, Ethiopia has a promising and expanding digital ecosystem with a growing telecommunication infrastructure that could be a stepping stone for its wider application in the digitalization and automation of the agricultural mechanization value chain. The country needs to benefit its agriculture by benchmarking experiences of other countries, which have undergone similar growth paths.

With this understanding, the following basic benchmarking or performance improvement steps from the below indicated countries, like the success achieved by the country in the promotion and expansion of

2-wheel tractors (2WT), as well as the small horsepower (40-90 HP) four-wheel tractors (4WT) ***from Bangladesh***. The process and establishment of ***Agricultural Machinery industries*** including harvesting, processing, and value addition of coffee from ***Vietnam***. ***Employing precision agriculture*** using GIS/GPS and the application of AI from ***India***, as these identified countries are to have similar economic growth paths and government setups as well as farming systems in fragmented land owned by smallholder farmers, Ethiopia can draw a lesson to enhance its agricultural mechanization development.

In general, benchmarking countries were selected based on mechanization technology diversification and usage for all-level farm-holders, appropriate mechanization technology application for fragmented land, technology manufacturing and generation, agricultural mechanization services, reliance of the majority of farmers on agriculture, slopes and topography of lands, mechanization technology promotion, and agricultural mechanization impacts of agricultural production and productivity growth.

Bangladesh

The agriculture of Bangladesh is characterized by overwhelmingly small holdings due to higher population density and nearly 80% of its population residing in the rural areas, coupled with unabated land fragmentation due to the inheritance laws of the country. Small farms and limited purchasing power of farmers. Bangladesh has managed to promote mechanization by using 2WT and small- to medium-HP 4WT

tractors to address the need of smallholder farmers for mechanization. Even though small and fragmented lands restrict the farmers from using larger-sized farm machinery, at present, 80% of the land is prepared by power tiller or 2 WTs and 18% by 4 WTs.

The experience of the Machinery Hub establishment, by the cooperatives, private individual farmers, and private service providers to address the traditionally called "disadvantaged group," who own less than 1.5 ha and work out of cluster farming areas, has spurred farm machinery hiring services. In the 1960s, there was a 75% subsidy scheme for farmers. Due to the prevailing small landholdings, many farmers who own agricultural machines opt for hiring out these machines in addition to operating their own land.

Vietnam

Vietnam is the world's number two producer of coffee and number one producer of Robusta. Vietnam has been second only to Brazil in world coffee exports; however, coffee farmers, producers, and traders in the Central Highlands now increasingly use machines to dry cherries. Moreover, for intensive processing of coffee products (roasted, ground, and soluble coffee) and value addition, there are 176 facilities. Vietnamese-manufactured power tillers have been substituting imported power tillers since the 1990s; Kubota tractors sold in Vietnam are, however, modified to be much stronger and more durable than those manufactured and used in Japan. The manufacturing of tractors and agricultural mechanization technologies is driven by a government act,

happens to be highly successful, and has enabled the country to substitute agricultural machinery imports.

India

India's experience of a holistic value chain approach in the digitalization of agricultural mechanization has gone beyond the successes of the green revolution that was waged earlier. India, in agriculture and its subsectors, moved towards precision and digital agriculture through the application of robotics, the Internet of Things (IoT), and artificial intelligence (AI), including the capacity to develop and manufacture sensors, navigation, and automated technologies that are applied in agricultural machinery, like forage and feed manufacturing, livestock, and fishery development technologies. India's human resource capacity building programs, in the digitalization of agriculture, to utilize the technologies for tracking, data capture, analysis, and interpretation for informed decision-making, coupled with its integrated development, is worth benchmarking to improve our performances in agriculture and uplift our economic growth.

Experience from Africa

Three African countries (Nigeria, Ghana, and Kenya) have been taken for benchmarking due to the following similarities and communalities: low level of agricultural mechanization, rugged terrain and landscape and agro-ecology, fragmented and small-scale farmers, implementation of government-led (starting from 1970) mechanization programs, similar setbacks because of mismanagement and high cost of operation, lack of good governance, and limited involvement of the private sector, as well

as being highly import-dependent for technologies.

After 30 years, the following shifts occurred: decreasing of government involvement, establishment of the SKD tractor assembly plant (the case of Ghana and Nigeria), allowing of some components to be manufactured locally, continually growing private involvement and government policy support, and digitalization of mechanization services, including maintenance for optimization (the case of Kenya). In conclusion, Ghana, with a government and private partnership (PPP), was successful in establishing a joint venture tractor assembly plant (*the hardware*) with an international company and reduced its costly dependency on tractor imports. Kenya optimized and increased its tractor use efficiency through digitalizing the value chain of mechanization services (*the software*).

Ethiopia's takeaway should be the establishment of an assembly plant through a joint venture and going digital for greater efficiency and optimization of mechanization use by blending the experiences of both Ghana and Kenya.

3.8. SWOT analysis for agricultural mechanization

Table 4. SWOT analysis

Strength(S)	Weakness (W)	Opportunity (O)	Threats (T)
1) Policy, legal framework, institutional arrangement, and finance			
▪ Focus of new approved ARD policy for agricultural mechanization ▪ Commitment to revise and develop national agricultural mechanization strategy ▪ Continuous effort to engage more stakeholders ▪ Decision made on exemption of agricultural mechanization technologies from duties and taxes, including mechanization services from VAT	▪ Inadequate number of mechanization Service centers ▪ Inadequate number and quality of higher learning institutions, ATVET college & training centers ▪ Limited skilled professionals and technicians ▪ Absence of directives and guidelines to ensure standards of imported and locally manufactured agricultural machineries and mechanization technologies service provision ▪ Lack of integration and linkage among sectors ▪ Lack of well-organized agricultural mechanization structure in most of the regions	▪ Presence of the new agricultural and rural development policy ▪ Growing the availability of lease financing ▪ Macroeconomic reform creating conducive environment to access finance ▪ Presence of pluralistic extension systems to engage private sectors ▪ Presence of public-private-partnership legal framework ▪ Existence of tax and duties exemptions, of agricultural mechanization technologies and including mechanization service from VAT ▪ Existence of a land policy allowing farmers to use land certificate as credit collateral	▪ Rising machinery and spare parts cost due to inflation ▪ Rising costs of fuel and services for machinery operation ▪ Negative impact of Climate change ▪ Absence of tax exemption and other incentive packages for local machinery manufacturers. ▪ Decline number of graduate agricultural Engineers from higher learning institutions ▪ Inadequate availability of infrastructure facilities and fuel stations for farm machinery

Strength(S)	Weakness (W)	Opportunity (O)	Threats (T)
▪ Institutionalizing agricultural Mechanization at the federal level and some regions ▪ Existence of agricultural mechanization skill training centers ▪ Established agricultural mechanization Service centers ▪ Improved access to finance for agricultural mechanization technologies	▪ Limited capacity building programs for existing professionals and technicians ▪ Weak agricultural mechanization research and extension linkage. ▪ Limited capacity (man-power, facilities, etc.) of agricultural mechanization research centers ▪ Inadequacy of available financial products for agricultural mechanization technologies ▪ Lack of 'Agricultural Mechanization fund' for innovations ▪ Absence of 'Agricultural Bank' ▪ Absence of testing, certification, and regulatory services to ensure quality of machineries and provided services	▪ Establishment of Agricultural Mechanization Center of Excellence ▪ Presence of mechanization research and development systems ▪ Growing involvement of stakeholders and development partners in supporting mechanization activities ▪ Presence of private and public Mechanization training Centers and ATVET colleges ▪ Growing of mechanization Service centers	

Strength(S)	Weakness (W)	Opportunity (O)	Threats (T)
2) Research and technology development			
▪ Improved agricultural mechanization research culture and experience ▪ Focus given for mechanical power technologies ▪ Existence of research professionals at medium-level ▪ Starting of smart agriculture mechanization technologies at research system ▪ The effort to Establish agricultural mechanization Center of Excellence	▪ Limited number of mechanization technology generation ▪ Lack of appropriate mechanization technologies fitting to the different needs of farmers, farming systems and agro-ecology ▪ Less attention given for livestock and natural resource technologies ▪ Weak design and adaptation capability of mechanization technology ▪ Less attention given to medium and large-scale mechanization technologies ▪ Limited number and capacity of agricultural mechanization research centers	▪ The initiation of technology innovation by private companies and individuals ▪ Existence of proven and adaptable technologies ▪ Awareness of mechanization by farming community ▪ Engagement of different partners for supporting agricultural mechanization ▪ Rising of digitalization and AI support for agricultural mechanization practice ▪ Available potential educated youth to use released agricultural mechanization technologies	▪ Degradation of natural resources ▪ Climate change ▪ Rising raw materials costs for research activities

Strength(S)	Weakness (W)	Opportunity (O)	Threats (T)
3) Production/Assembling			
▪ Increased imitation and government support to expand production and assembling plants ▪ Creating conducive environment to import SKD and assembly, and CBU agricultural machinery ▪ Motivate private agricultural machinery manufacturing companies ▪ Availability of raw materials for local manufacturing machinery	▪ Limitation of prototypes by productions systems ▪ Less focus of existing small- and large-scale manufacturing industries, for agricultural mechanization technologies ▪ Limited number and kind of mechanization technologies for agricultural production and productivity ▪ Lack of awareness and entrepreneurial skill on manufacturing agricultural mechanization technologies	▪ The growing of manufacturing industries ▪ Increased awareness of farmers to use agricultural mechanization ▪ The commitment of government for expansion of agricultural mechanization technologies ▪ Existence of educated youth to join the industry ▪ Expansion of cluster farming which increase the demand for agricultural mechanization technologies ▪ Increased promotion, supply, and services of agricultural mechanization technologies. ▪ Increased private and cooperative unions engagement in agricultural mechanization hiring services ▪ Growing of awareness on locally manufactured agricultural mechanization technology	▪ Rising raw material price due to high inflation and global market fluctuation ▪ Limited number of manufacturing and assembling industries focusing on agricultural mechanization technologies ▪ Limited initiations to adopt Digital, precision, and smart agriculture

Strength(S)	Weakness (W)	Opportunity (O)	Threats (T)
4) Marketing/Promotion and distribution			
▪ Created awareness and promotion on agricultural mechanization utilization ▪ Increased use of improved transport, storage, and handling facilities for agricultural products ▪ Effort to promote mechanization technologies through bazar, symposium, forum, and media outlets	▪ Limited mechanization technologies for horticultural and livestock productions ▪ Limited cold storage, cold chain, processing and packing technologies for perishable agricultural products ▪ Lack of innovated and generated agricultural mechanization technology transfer, multiplication, and dissemination systems. ▪ Lack of promotion enactment for agricultural mechanization technologies	▪ Growing availability of rural infrastructure (roads, power, communication) ▪ Commercialization initiatives, flagship interventions—wheat, rice, livestock ▪ Increased emerging rural towns with market access to expand mechanization service which increase demand of mechanization technologies ▪ Increased access to finance and purchasing power of farming community	▪ Inflation on agricultural machineries and service ▪ Unpredictable geopolitical situation and international market fluctuation ▪ Limited access to foreign currency
5) Consumption/usage			
▪ Growth of alternative technologies by type and-scale. ▪ Improved awareness and extension advisory service ▪ Increasing the number of farmers to use agricultural mechanization	▪ Inadequate promotion, awareness creation & use of improved storage technologies, transportation facilities, and others post-harvest technologies ▪ low knowledge and skill in usage of machineries	▪ Relatively good infrastructure expansions ▪ Commercialization initiatives, Flagship interventions—wheat, rice, and livestock ▪ The existence of agro-industry Growth Corridors (17 selected) agro-industrial parks	▪ Rising cost of farm machineries ▪ Knowledge gaps on technology usage

Strength(S)	Weakness (W)	Opportunity (O)	Threats (T)
▪ Government initiatives to boosting agricultural products improves the usage of agricultural mechanization technologies. ▪ Emphasis of government and encouraging growth of small, medium, and large-scale agro-processing industries ▪ Encouraging growth of small-scale processing machinery generation at research institutions, private sectors, high learning institution and TVET improves usage	▪ lack of manuals and materials provision with agricultural machineries ▪ Intermittent, seasonal working periods contributing for hourly cost of operation and reducing machinery profitability ▪ Limited supply of appropriate technologies for fragmented land ▪ Low attention given to diversify tractor power utilization efficiency ▪ Limited agricultural mechanization extension and advisory services ▪ Use of old machineries	▪ Diversification of consumption pattern	

6) Aftersales services			
▪ Establishment of mechanization service centers ▪ Increased number of agricultural mechanization technologies dealers and aftersales service provision	▪ Limited aftersales services for mechanization technologies ▪ Lack of dealers' standards ▪ Inadequate provision of training on mechanization technologies service ▪ Insufficient availability of spare parts	▪ Government commitment to increase number of MSC and other service providers	▪ Price escalation on spare parts due to inflation ▪ Lack of standard quality of aftersales service

PART FOUR
ELEMENTS OF THE STRATEGY

4.1. Vision

By 2035, aspire to see a mechanized agricultural production system that will contribute to agricultural transformation, economic development, and prosperity of the country.

4.2. Mission

- Generate, adapt, test, demonstrate, multiply and popularize suitable and appropriate agricultural mechanization technologies for end users that improve productivity, efficiency, and sustainability of different agricultural production system,
- Create an enabling policy environment, institutional arraignment, and capacity allowing active engagement of public and private actors in manufacturing and assembly of agricultural mechanization technologies
- Ensure and expand after-sales, maintenance, renting, training service provisions in different production system to enhance sustainable utilization of agricultural technologies by end users,
- Strengthen testing and certification centers to standardize agricultural mechanization technologies and service provision,
- Engendered agricultural mechanization technology and service provision in which men, women, youth, and marginalized segment of the society participate and share benefit,

4.3. Strategic goals

a) Crop development mechanization technologies

- **Increase farm power density: -** double the national farm power level from 1.36 units to 4.1 units of tractor per 1000 ha of arable land.
- **Combine harvesters' utilization: -** the level of combine harvesters' utilization from the current status of 0.66 to 1.99 combine harvesters per 10,000 ha of harvested field/land.
- **Increase crop yields via precision equipment: -** increase the existing level of fertilizer and seed application precision equipment from the current level (0.5%) to 30% to optimize resource use efficiency.
- **Reduce post-harvest losses through mechanization technologies:-** reduce national post-harvest losses of cereals from the current level (27%) to below 10% and horticultural from the current level (40%) to below 20% of total yield.
- **Increase the level of mechanization technologies used per production cluster:** - increase utilization of mechanization technologies per smallholder production cluster from the current status (25%) to 80%

b) Livestock and fishery development mechanization technologies

- **Ensure livestock products' global quality and safety compliances: -** ensure 100% of export-destined livestock products meet global quality and safety compliances (sanitary

and phytosanitary) through the application of mechanization technologies,

- **Modernize the sustainable supply of feed supply: -** ensure 75% of small-scale and commercial-scale animal feed utilizes improved mechanized processing.
- **Improve adoption rate of mechanized technologies: -** increase the adoption rate of modern mechanized pre- and post-harvest processing technologies among livestock product producers by 50%.

c) Natural resource management mechanization technologies

- **Improve soil health through mechanization technologies: -** By 2035, achieve a 40% reduction in net soil fertility degradation across major agricultural watersheds through the widespread adoption of conservation agriculture practices.
- **Enhance water efficiency through mechanization technologies:** By 2035, increase the scale of appropriate mechanization technologies per irrigable land from the existing status of 99 to 297 irrigation pumps to 1000 ha.
- **Reduce CO_2 emissions:** By 2035, contribute to reduced levels of CO_2 emissions through the adoption of environmentally friendly advanced mechanization technologies,

4.4. Objective of the strategy

To improve agricultural efficiency, production, and productivity, reduce production losses; and ensure sustainable livelihood through the application of appropriate agricultural mechanization technology.

4.5. Values

- Farming system oriented and agroecology based
- Market-oriented
- Quality and safety
- Partnership
- Experience and practice
- Creativity and innovativeness
- Equality and equity
- Timeliness
- Collective action
- Transparency and accountability
- Participatory and inclusiveness
- Digitization
- Environment friendly

4.6. Scope of the strategy

Mechanization of agriculture has a very broad context. It is not limited to crop and livestock value chain mechanization. But the overall scope of the term "agricultural mechanization" consists of several components: technology manufacturing, importation, distribution, after-sales service provision (supply of spare parts, maintenance and repair, and provision of training), mechanization service provision, machinery operator and mechanics training, agricultural machinery handling, machinery selection and management, machinery disposal and replacement, agricultural machinery fleet management, etc. Even though the above-mentioned elements are the main function, agricultural mechanization

has cross-cutting issues. Rural infrastructure (roads, electricity, fuel stations, telecommunication, water facilities) and financial institutions, etc. are pillars for mechanizing agriculture. Due attention must be paid to ensure that this system functions in an integrated manner. For the mechanization sector to function well, all the individual components must be in place, and all must be working efficiently. Therefore, the interdependent relationships of the various components as well as the linkages between them are crucial for the betterment of mechanization systems operation. The strategy shall be implemented nationally by relevant public, NGOs, and private sectors to benefit farmers, pastorals, agro-pastorals, large commercial and investment farms, and investors across the country.

4.7.Theory of change

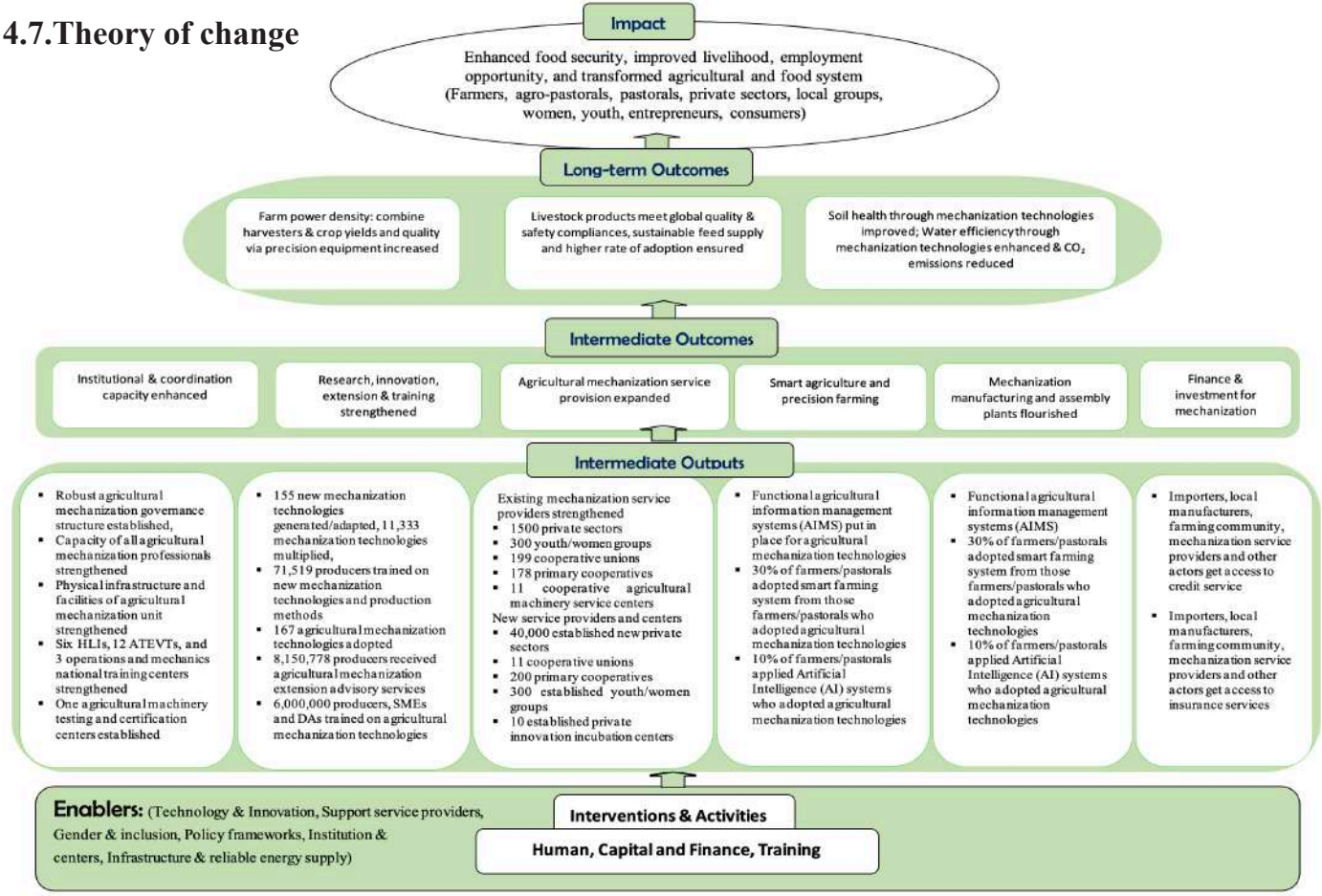

Figure 1. Theory of change for agricultural mechanization development in Ethiopia

PART FIVE
STRATEGIC PILLARS, ENABLERS, AND INSTITUTIONAL ARRANGEMENT

5.1. Strategic Pillars and Interventions

5.1.1. Institutional capacity and human capital development

Strategic objective (SO1): Strengthen institutional capacity and multi-sectoral coordination and integration for agricultural mechanization

Strategic directions

- Capacity of institution shall be strengthened and equipped with qualified human resources, modern physical facilities, up-to-date technologies, and other necessary resources essential to ensure responsiveness to emerging challenges and opportunities, and achieve sustainable agriculture mechanization development and effective service delivery in the country.
- Harmonious collaboration and integration shall be fostered and enhanced among various stakeholders involved in agricultural mechanization activities by establishing clearly defined shared goals, delineating roles, and assigning responsibilities to ensure effective and sustainable outcomes.
- Standardize institutional arrangement and structural reform shall be cascaded at the federal and regional levels to ensure effective functioning, coordination, and implementation

based on the prevailing conditions of the federal and regional institutions.

- Expand and reinforce education and training resources that will ensure the production of competent professionals with the necessary knowledge and skills for the growing needs of the sub-sector.

Expected output 1:

Established robust agricultural mechanization governance structure at federal and in all regions,

Intervention:

Establish reinforcing mechanism that comply with standard governance structure both at federal and regional levels

Activities

- Conduct situation analysis and identify structure-related gaps at all level
- Establish agricultural mechanization structure aligned between federal and regional levels
- Solicit human and financial resources for mechanization projects,
- Review and update existing and relevant policy support and structural reforms,
- Establish multi-stakeholder and discipline platforms at federal and regional levels,
- Establish key performance indicators to track, monitor and evaluate the progress and impacts of mechanization initiatives,

Expected output 2:

Strengthened the capacity of all agricultural mechanization professionals at all levels

Intervention:

Develop and implement human capacity building programs to achieve short- and long-term goals in agricultural mechanization

Activities

- Conduct training needs assessment among agricultural mechanization professionals,
- Develop capacity building roadmap, training strategic plan and training manuals,
- Conduct successive and tailor-made training activities for professionals in the field
- Organize international experience sharing and exposure visits,
- Establish Memorandum of Understanding (MoU) with local and international training institutions,

Expected output 3:

Strengthened physical infrastructure and facilities of federal and regional agricultural mechanization unit at all levels,

Intervention:

Develop and implement comprehensive physical capacity building programs

Activities

- Conduct physical infrastructure gap assessment and compare current state of condition against desired standards/best practices,
- Identify potential funding sources (government budget, development partner grants, private investment) and respond to prioritized needs,
- Establish progress tracking system for continuous improvement,

Expected output 4:

Strengthened agricultural mechanization training provision capacities of six higher learning institutions, 12 ATEVTs, and 3 operations and mechanics national training centers

Intervention:

Capacitate higher learning institutes (HLI) with qualified personnel, physical, training and teaching resources

Activities

- Conduct needs assessment among higher learning institutions (HLI), ATEVTs, and training centers
- Develop and implement human and physical capacity building programs
- Establish linkage mechanism between higher learning institutions/ATEVTs/ training centers with mechanization manufacturing, and assembly plants,
- Promote innovative research in the higher learning institutions

- Organize experience sharing and staff exchange programs among local and international institutions

Expected output 5:

Established one agricultural machinery testing and certification centers

Intervention:

Put in place a working system to establish and run testing and certification centers

Activities

- Conduct farming system-based needs and requirements study for testing and certification,
- Establish testing and certification center
- Equip the centers with necessary laboratories, testing equipment, tools, and technologies

5.1.2. Research, innovation, extension, and training

Strategic objective 2 (SO2): Strengthen agricultural mechanization research, innovation, extension, and training,

Strategic directions

- Research programs will focus on strengthening efforts to develop innovative, efficient, cost-effective, and environmentally friendly mechanization technologies suitable for several farming systems/agro-ecologies.
- The strategy will place emphasis on adapting and tailoring

internationally available mechanization innovative solutions/ technologies to our farming system and specific needs of commodity types/sub-sectors.

- Significant efforts will be made to strengthen extension advisory services to demonstrate/showcase available technologies and provide farmers with the knowledge and skill needed to effectively apply and adopt mechanization technologies.
- An institutional arrangement will be established to effectively provide technical training programs to farmers, extension Subject Matter Specialists (SMS), and development agents on the operation and maintenance of mechanization technologies.
- Emphasis will be placed on ensuring private sector participation in the development, multiplication, and dissemination of agricultural mechanization technologies.

Expected output 1:

75 generated/adapted new and suitable agricultural mechanization technologies and 60 introduced with new agricultural mechanization information for end users for agricultural crops.

Intervention:

Capacitate technology development and multiplication capacity (human resources, facilities and infrastructure/field stations, and capital) and technology transfer of agricultural research centers for crops.

Activities

- Conduct capacity gaps/needs assessment in response to existing and emerging challenges,
- Develop and implement capacity building activities for agricultural mechanization research programs/centers for crops.
- Identify and secure potential findings from government, private sectors, and international donors to support the research program for crops,
- Develop, adapt, and multiply mechanization prototypes suitable for several farming systems
- Establish multi-stakeholder platforms to facilitate linkage between research institute/HLIs with local industries for collaborative projects,
- Shopping appropriate mechanization technologies from technology generation sources or origin

Expected output 2:

60 generated/adapted new and suitable agricultural mechanization technologies and 43 introduced with new agricultural mechanization information for end users for livestock and bee farming.

Intervention:

Strengthen technology development and multiplication capacity (human resource, facilities and infrastructure/field stations, capital) and technology transfer of agricultural research centers for livestock.

Activities

- Conduct capacity gaps/needs assessment in response to existing and emerging challenges,
- Develop and implement capacity building activities for agricultural mechanization research program/centers for livestock.
- Identify and secure potential findings from government, private sectors, and international donors to support the research program,
- Develop, adapt, and multiply mechanization prototypes suitable for the livestock value chain
- Establish multi stakeholder platforms to facilitate linkage between research institutes/HLIs with local industries for collaborative projects pertinent to livestock,
- Shopping appropriate mechanization technologies from technology generation sources or origin

Expected output 3:

20 generated/adapted new and suitable agri-lime spreader/ spinning disc agricultural mechanization technologies, and 913 introduced with new agricultural mechanization information for end users, and 15 generated limestone crushers for soil health.

Intervention:

Strengthen technology development and multiplication capacity (human resources, facilities, and infrastructure

field stations, capital) and technology transfer of agricultural research centers for soil health.

Activities

- Conduct capacity gaps/needs assessment in response to existing and emerging challenges pertinent to soil health and soil fertility management,
- Develop and implement capacity building activities for agricultural mechanization research program/centers for soil health.
- Identify and secure potential findings from government, private sectors, and international donors to support the research program pertinent to soil health,
- Develop, adapt, and multiply mechanization technology prototypes suitable for soil health.
- Establish multi- stakeholder platforms to facilitate linkage between research institutes/HLIs with local industries for collaborative projects pertinent to soil health,
- Shopping appropriate mechanization technologies from technology generation sources or origin

Expected output 4:

11,333 multiplied by mechanization technologies, 15,723 producers introduced to new agricultural mechanization technologies and modern production techniques, and 71,519 producers trained on new mechanization technologies and production methods for crops, livestock, and soil health.

Intervention:

Strengthen the two-way research-extension linkages, facilitating the exchange of new mechanization technologies

Activities

- Conduct a joint planning workshop aligning with existing needs and challenges
- Establish a string and technical working group tracks progresses and outcomes,
- Establish regulatory compliance for the release and registration of new agricultural mechanizations
- Develop an annual technology inventory report ready/ available for introduction and wider dissemination,

Expected output 5:

Number of agricultural mechanization technologies adopted and producers received agricultural mechanization extension advisory services

- 31 agricultural mechanization technologies adopted for crop production
- 121 agricultural mechanization technologies adopted for livestock and fishery production

- 15 agricultural mechanization technologies adopted for soil health, forest fire, and forest mechanization
- 8,150,778 producers received agricultural mechanization extension advisory services for crop production and livestock, fishery, and natural resources

Intervention:

Develop packages of agricultural mechanization technologies adaptable and suitable to end users

Activities

- Characterize agricultural mechanization technology requirements for different farming systems,
- Organize a team of experts to develop extension packages for agricultural mechanization,
- Develop and dispatch communication materials to provide extension advisory services
- Conduct result and method demonstrations, field days, technology fairs, etc. to popularize technologies to the end users,
- Established agricultural mechanization demonstration and training centers
- Promote/introduce agricultural mechanization technologies to producers/end users through agricultural mechanization extension and media outlets
- Establish a tracking and feedback system to monitor and evaluate progress and outcomes,

Expected output 6:

6,000,000 producers, SMEs, and DAs trained on agricultural mechanization technologies

Intervention:

Capacitate producers, SMEs and DAs with innovative

mechanization solution, best practices, and modern techniques.

Activities:

- Equipping farmers' and pastoralists' training centers with demonstration facilities based on the production system
- Develop a training curriculum for farmers and pastoralists training centers
- Conduct package training for producers, SMEs, and DAs

5.1.3. Agricultural mechanization service provision

Strategic objective 3 (SO3): Promote and strengthen digitalized and diversified agricultural mechanization service provision across the production system

Strategic directions

- Focus will be placed on encouraging the private sector, youth, and cooperatives to provide agricultural mechanization services to producers, equipped with the necessary tools, technologies, and supports.
- Emphasis will be placed on favorable policy support to encourage private sector investment to establish robust mechanization service centers. These centers will provide rental and related services (including maintenance, training, and spare part provision) for agricultural machinery and equipment directly to end-users.

Expected output 1:

Strengthened/established agricultural mechanization innovation, business incubation and service centers

Existing service providers

- 1500 strengthened private machinery services providers
- 300 strengthened youth/women group machinery service providers
- 199 strengthened cooperative union machinery service providers
- 178 strengthened primary cooperative machinery service providers
- 11 strengthened cooperative agricultural machinery service centers

New service providers and centers

- 40,000 established new private mechanization service providers
- 11 cooperative unions involving in agricultural machinery service provision
- 200 primary cooperatives involving in machinery service provision
- 300 established youth/women group machinery service providers
- 10 established private innovation incubation centers

Intervention:

Develop alternative business models for agricultural mechanization innovations and business,

Activities

- Conduct need assessment on agricultural mechanization service provision based on production system
- Develop agricultural mechanization service provision guideline
- Develop agricultural mechanization service provision business models
- Strengthening the capacity of service providers on business & technical skill.
- Establish standards to monitor the quality-of-service delivery
- Establish one stop shopping services centers
- Devise incentive mechanism to encourage private sectors
- Establish continuous follow-up and support system for the quality and access of service provision

Expected output 2:

Put in place a digital platform to provide, monitoring and evaluate agricultural mechanization services

Intervention:

Develop a digital platform that enable agricultural mechanization service provision

Activities

- Conduct assessment to identify demand and capacity to use digitalized mechanization services
- Develop applications and establish digital platform to access and enhance agricultural mechanization services

- Conduct training on digital technology application and usage for service providers and customers
- Conduct customers mapping and create digital database for service providers and end users to enhance linkage
- Continuous follow-up and support on accessibility and quality of digital mechanization services

5.1.4. Smart agriculture and precision farming

Strategic Objective 4 (SO4): Enhance the application of digital agriculture, precision farming and Artificial Intelligence (AI) application in agricultural mechanization for both urban and rural agriculture

Strategic direction

- Emphasis shall be put in place to modernize agriculture through promotion and utilization of digital and smart farming system and application of AI.

Expected output 1:

Functional agricultural information management systems (AIMS) put in place for agricultural mechanization technologies

Intervention:

Develop, domesticate, and roll out agricultural information management systems (AIMS) friendly to end users

Activities:

- Conduct gap assessment on the existing mechanization technologies data management systems
- Develop content and establish data base for mechanization technologies
- Establish mechanization technology inventory system
- Develop mechanization technology registration, management, and disposal system
- Conduct capacity building trainings at federal and regional level on data management system
- Create awareness for stakeholders and partners to increase their participation and involvement in mechanization technologies data management system
- Conduct support and follow up for data management system at all level

Expected output 2:

30% of farmers/pastorals adopted smart farming system from those farmers/pastorals who adopted agricultural mechanization technologies

Intervention:

Develop, pilot, and promote packages of smart farming methods to end users in different production system,

Activities

- Conduct need assessment for smart farming systems
- Promote importance of smart farming systems

- Promote smart farming in urban agriculture
- Establish geospatial systems to implement and use of smart farming
- Provide capacity building training on smart farming
- Identify and select pilot areas and promote smart farming based on production system
- Conduct experience sharing program
- Compiling best practices for scaling up the implementation smart farming

Expected output 3:

10% of farmers/pastorals applied AI systems who adopted agricultural mechanization technologies

Intervention:

Integrate AI system to support farming system based agricultural mechanization initiatives,

Activities

- Conduct need assessment for application of AI in farming systems
- Promote importance of AI in farming systems
- Establish machine learning system for robotic application in farming system
- Provide capacity building training on AI application in farming system
- Identify areas of application of AI in farming system.
- Conduct experience sharing program

- Compiling best practices for scaling up the implementation precision farming
- Continuous follow-up and support

5.1.5. Financial services and investment

Strategic Objective 5 (SO5) Improve financial support and access to credit services for agricultural mechanization technologies along the value chain

Strategic direction

- Focus will be placed on increasing loan availability and portfolio by developing microfinance/rural /agricultural banks and loan grantee schemes to provide importers, local manufacturers, farming community, mechanization service providers and other actors with access to financial supports and affordable credit services to purchase, rent machineries and run business activities
- Policy supports and institutional supports will be established to expand rural insurance services for agricultural mechanization and related business activities,

Expected output 1:

Importers, local manufacturers, farming community, mechanization service providers and other actors get access to credit service

Intervention:

Establish a working procedure to enhance access to credit services tailored to agricultural mechanization,

Activities

- Conduct situation analysis on accessibility of financial supports and affordable credit services for agricultural mechanization
- Establish mechanization focused finance and credit programs in microfinance and banks using movable and unmovable assets,
- Establish PPP to pool financial resources supporting business models
- Conduct capacity building programs to train end users financial management skills,
- Initiate agricultural mechanization fund to solve financial burden for agricultural mechanization technologies
- Support to institute agricultural mechanization finance in agricultural bank

Expected output 2:

Importers, local manufacturers, farming community, mechanization service providers and other actors get access to insurance services

Intervention:

Expand insurance services in rural areas for agricultural mechanization,

Activities

- Develop community-based insurance programs enable to address specific needs of end users
- Develop and reinforce legal frameworks regulating insurance services affordable and tailored to financial capacity of end users,
- Conduct awareness campaign to educate end users about the access to and benefits of insurance services,
- Expand access to insurance services through digital means and smart phones facilitating enrolments with wider coverage including remote areas

5.1.6. Agricultural mechanization technologies manufacturing and assembly plants

Strategic objective 6 (SO6): Initiate and collaborate to establish manufacturing and assembly plants through Public Private Partnership,

Strategic direction

- Policy supports, legal frameworks and working procedures shall be put in place to increase the number of foreign and local private investors involving in agricultural mechanization technology manufacturing and assembling business.

Expected output 1:

Manufacturers and assembly plants strengthened and established by foreign and local investors

Existing manufacturing and assembly plants

- 1000 strengthened small-scale local manufacturers
- Four strengthened local assembly plants

Establish new manufacturing and assembly plants

- 4000 established small scale local manufacturers
- Two established large-scale local manufacturers
- 10 established local assembly plants

Intervention:

Organize special manufacturing and assembling zones with standard infrastructure and maintain international and local level relations through events/fairs, etc.

A**ctivities**

- Collaborations established, and agreements concluded to establish manufacturing and assembling plants.
- Conduct a need assessment study, in collaboration with the concerned institutions for agricultural mechanization technologies.
- Develop an incentive package to attract foreign and local investors, for manufacturing and assembly.
- Conduct a site assessment study to indicate alternative strategic location of the plant.
- Work with the responsible institution to avail land and develop infrastructure.
- Develop dealers' standards for mechanization technology importers and assemblers

Expected output 2:

Ensure quality assurance of agricultural machinery technologies manufactured, assembled, and imported.

Intervention:

Develop regulatory framework comply to local and international standards and best practices,

Activities

- Develop national standards, testing and certification procedures for agricultural mechanization technologies.
- Establish testing and certification center.
- Ensure the use of standards in the design of agricultural machinery
- Develop standards for raw materials used for the construction agricultural mechanization technologies.
- Develop and enforce standards for agricultural machinery at the point of entry

5.1.7. Crosscutting issues in agricultural mechanization

Strategic objective 7 (SO7): Ensure agricultural mechanization initiatives respond to the diverse needs and resource base of several segments of the society and climate change and the environment

Strategic directions

- International and national legal frameworks shall be popularized and enforced to ensure the participation and benefit of women, youth, and those in need of special

supports.

- Eco-system friendly and sustainable agricultural mechanization research and development practices will be promoted to minimize environmental impacts and enhance biophysical environment health.

Expected output 1:

50% women, youth and people with special needs participated in agricultural mechanization initiatives,

Interventions:

Improve and expand agricultural mechanization technologies for women, youth, and people with special needs.

Activities:

- Conducting gap assessment on mainstreaming crosscutting issues in agricultural mechanization technologies utilization and service.
- Develop operational guideline for mainstreaming crosscutting issues in agricultural mechanization technologies utilization and service.
- Conduct capacity building trainings for agricultural mechanization professionals and service providers on inclusive mainstreaming of crosscutting issues
- Prepare and implement gender, youth, and people with special needs mainstreaming plan
- Organizing and engaging youths in agricultural mechanization services

- Promote agricultural mechanization technologies that reduce drudgery of women's and peoples with special need.
- Promote agricultural mechanization technologies that enhance food safety in production and processing of agricultural products
- Promote agricultural mechanization technologies not contributing to climate change
- Promote agricultural mechanization technologies that reduce emission of methane gas to the environment

Expected output 2:

Fully food and nutrition mainstreamed mechanization technology development and popularization,

Intervention:

Put in place a working system to mainstream food and nutrition issues in mechanization technology development and popularization,

Activities

- Develop food and nutrition mainstreaming guideline for mechanization
- Improve awareness among researchers, experts, private sectors, and end users
- Ensure food and nutrition sensitive agricultural mechanization practices across the value chain,

Expected output 3:

50% reduced CO_2 emission in the use of fuel agricultural mechanization technologies

Intervention:

Apply exhaust gas emission regulation and control mechanism for self-propelled agricultural machinery

Activities:

- Create awareness of the effect of exhaust gas emissions on the environment
- Test the amount of carbon monoxide and carbon dioxide emitted from agricultural machinery
- Expand alternative electric and solar energy sources for agricultural mechanization equipment
- Enforce machinery owners to install catalytic converters to those machines measured emission is above the limit
- Identity and control machinery contributing to exhaust gas emission

Expected output 4:

Created disposal system for scraped agricultural mechanization technologies

Intervention:

Develop and put in place a disposal system for scrap and technically obsolete agricultural machinery and equipment

Activities

- Conduct assessment of the disposable machinery and equipment

- Create awareness of the effect of scrap machinery on the environment (Scrap machinery parts release contaminants like lead, mercury, and arsenic into the air, water, and groundwater, which can harm human health, animals, and plants) of machinery and handling systems.
- Initiate property administration and disposal agency to dispose of scrap and technically obsolete machinery and equipment

Expected output 5:

Put in place safe use and disposal for used/burned oil and lubricants applied agricultural machineries

Intervention:

Develop regulations and guidelines for the disposal of burned oil and grease released into the environment

Activities

- Conduct assessment of how machinery owners handle and dispose burned oil and grease
- Effect and popularize regulation and guidelines for wider adoption and enforcement,
- Create awareness for the machinery owners of all levels on burned oil and grease handling and disposal and instruct effect of burned oil and grease on soil, groundwater, and ecosystems

Expected output 6:

Improved awareness on sustainable use of biophysical environment in use of mechanization technologies

Intervention:

Promote and pilot suitable farming method packages specifically trailed to mechanization in different production system

Activities

- Conduct need assessment for suitable agricultural mechanization technologies and farming systems
- Plan availability, affordability, and introduction of technologies based on existing conditions and demand
- Promote the importance of conservation agriculture (conservation mechanization such as reduced tillage, machinery which incorporate plant residue with the soil farming systems)
- Provide capacity building training on conservation agriculture farming (conservation mechanization technologies
- Conduct experience sharing programs
- Compile best practices for scaling up appropriate farm machinery technologies
- Strengthen institutional support and partnerships
- Monitor and evaluate environmental impacts

Strategic Objective 8 (SO8):

Expand harmonized rural infrastructure and irrigation system for agricultural mechanization technologies.

Strategic directions

- Multi-stakeholder platform will be established to effectively facilitate the planned expansion of rural infrastructure and irrigation system that directly support mechanized farming operation, which will ensure coordinated efforts among various sectors and agencies involved in rural development.
- Cohesive and enabling policy environment will be created to incentivize and secure private sectors to invest in both the establishment and long-term maintenance of essential rural infrastructure and irrigation systems.

Expected output:

Expanded harmonized rural infrastructure, irrigation system, solar and other renewable energy systems for agricultural mechanization,

Intervention:

Improve and expand rural infrastructures such as rural road, rural electrification and renewable energy sources, telecommunication, fuel-station, and irrigation infrastructure for agricultural mechanization technologies.

Key activities

- Conduct gap assessment for rural infrastructures to expand agricultural mechanization services
- Collaborate with national and regional relevant public and private sectors to speed up the expansion of rural infrastructures

- Establish stakeholders' platform for integrated and harmonized rural infrastructure development for agricultural mechanization enhancement.
- Expand solar and other renewable energy sources for rural mechanization development

5.2. Enablers for agricultural mechanization strategy

Government policy and programs: The Ethiopian government has implemented various policy reforms and development programs aimed at promoting mechanization technologies in the agricultural sector. In the recent agricultural and rural development policies, agricultural mechanization is considered among the technologies that enable increasing the productivity potential of key factors of production, reducing pre- and post-harvest losses, improving product quality, enhancing primary-level value addition, and bringing an overall shift from subsistence to commercial orientation in the agricultural sector. In the policy, the emphasis is placed on increasing the availability of agricultural machinery by increasing the number of local manufacturing and assembly plants. The policy placed a strong emphasis on the private sector and cooperatives being engaged in service provision too. Furthermore, in order to increase the availability and accessibility of agricultural mechanization technologies and small-scale equipment appropriate for diverse production systems, as well as to expand associated services to rural areas of the country, the government gave tax exemptions for mechanization technologies imported from other countries. The government set up an institutional arrangement and

support service provisions to ensure farmers and pastoralists can access modern agricultural machinery and farming tools by designing multiple government programs, private sector engagement, and donor support.

Research and training infrastructure and facilities: In Ethiopia, there are more than 70 research centers located across the country tailored to the agro-ecologies and production systems of the country. Of these research centers, Kulumsa, Melkasa, Bako, Assela, Jimma, Mekele, Fedis, and Fogera are some of the front-line centers involved in testing and evaluating new machinery and farming tools and providing mechanization prototypes that improve farming practices. In addition to this, Haramaya, Jimma, Ambo, Hawassa, and Bahir Dar universities are some of the selected higher learning institutes engaged in research and training activities and generate and adopt agricultural mechanization technologies. In addition to public ATVET colleges, Kaleb Farmhouse and GS Training Center are the accredited private companies involved in mechanization short-term training activities. Furthermore, in Ethiopia, more than 1500 service providers assist smallholders with their farming operations and several machinery and farming equipment importers. However, it is reported that the demand for mechanization services exceeds the existing service providers and capacity. The country has skilled and unskilled human resources in different agricultural discipline areas, which provides an opportunity to execute the strategy successfully.

Rural infrastructure and logistics: Over the last three decades, Ethiopia's government has been investing in developing and expanding rural infrastructure. It has been possible to make great progress in road

development, allowing it to expand road networking throughout the country. Sources indicated that the road density has grown more than fourfold between 1951 and 2018. The growth has allowed agricultural mechanization to be spread to rural areas, paving the path for improved market access, lower transaction costs, and a greater socioeconomic impact in the country. The country launched the National Electrification Program (NEP) in 2017 to achieve access to electricity in both urban and rural areas. In this endeavor, it has been able to increase the number of towns and villages with access to electricity. In addition to this, the countries' investment to expand storage facilities, irrigation systems, telecom infrastructure, transportation logistics provide an enabling environment to successfully implement this strategy

5.3. Implementation Arrangements

Develop a mechanization implementation plan: by considering the policy directions, a detailed implementation plan shall be developed and implemented with a close collaboration among public, private, and development partners. The implementation plan outlines specific activities, timelines, responsibilities, and budgets, which are then broken down into manageable annual tasks and milestones to ensure that the identified interventions are implemented and the expected outputs are realized.

Establish a governance platform: agricultural mechanization is multidisciplinary in nature, implying that it requires the involvement of several public, private, and development partners to ensure its successful implementation. For the effective coordination and implementation of the

National Agricultural Mechanization Strategy, thus far, a comprehensive multi-stakeholder platform shall be put in place at both federal and regional levels. The platform constitutes a steering committee and a technical committee. The steering committee shall be the higher decision-making organ providing strategic leadership to guide the agricultural mechanization interventions in the country. The committee shall comprise selected relevant ministries, representatives from the private sector, farmer organizations and associations, development partners/ NGOs, and academic institutions. It will be chaired by the Ministry of Agriculture and co-chaired/secretarial by a representative of the private sector. The technical committee shall be the main advisory body working on the implementation of agricultural mechanization interventions in Ethiopia. The state ministry and mechanization lead executive officers shall chair the technical committee. The Ministry of Agriculture will be the lead institution in the coordination and implementation of the National Agricultural Mechanization Strategic Interventions. Several shareholders shall have a role in ensuring the successful execution of the national mechanization policy (see role and responsibility of stakeholders in Annex 1). Each stakeholder's active participation and effectiveness shall assist in achieving the desired results and have a concrete impact on the entire production system.

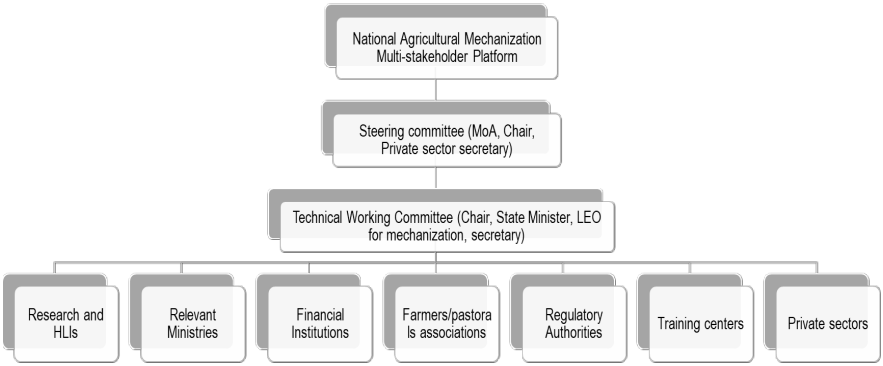

Figure 2. Governance structure of NAMS

Devise a strategy for the mechanization fund: to successfully implement a strategy and achieve its goals, it is crucial to have sufficient resources available, which can be achieved through a combination of approaches. It involves soliciting available funds from various sources such as the national treasury, private sector partnerships, corporate sponsorships, donation campaigns, micro-finances, commercial bank loans, research grants, international aid, and agricultural mechanization funds to ensure sufficient funds for strategy implementation. A fundraising strategy and donors' engagement plan shall be developed. Table 5 depicted the estimated budget required to implement the strategy.

Table 5. Budget required for the implementation of the strategy

No	Pillars	Expected outputs	Budget (USD in Million)	Responsibility
1	Institutional capacity and human resource development	Established robust agricultural mechanization governance structure at federal and in all regions, Strengthened the capacity of all agricultural mechanization professionals at all levels Strengthened physical infrastructure and facilities of federal and regional agricultural mechanization unit at all levels, Strengthened agricultural mechanization training provision capacities of six higher learning institutions, 12 ATEVTs, and 3 operations and mechanics national training centers Established one agricultural machinery testing and certification centers	16.8	MoA, BoA, HLIs, ATVET, Private training centers
2	Research, innovation, extension and training	155 generated/adapted new and suitable agricultural mechanization technologies and 116 introduced with new agricultural mechanization information for end users 11,333 multiplied mechanization technologies, 15,723 producers introduced with new agricultural mechanization technologies and modern production techniques and 71,519 producers trained on new mechanization technologies and production methods Number of agricultural mechanization technologies adopted and producers received agricultural mechanization extension advisory services 6,000,000 producers, SMEs and DAs trained on agricultural mechanization technologies	119	MoF, MoPD, MoA, BoA, EIAR, RARIs, ATI, HLIs, NGOs, CG Centers, Donors,

No	Pillars	Expected outputs	Budget (USD in Million)	Responsibility
3	Agricultural mechanization service provision	Strengthened/established agricultural mechanization innovation, business incubation and service centers	30.8	MoA, BoA, MoLS, Ethio-Telecom, Investment Commission,
		Put in place a digital platform to provide, monitoring and evaluate agricultural mechanization services		
4	Smart agriculture and precision farming	Functional agricultural information management systems (AIMS) put in place for agricultural mechanization technologies	119	MoA, ATI, Ethio-telecom, NGOs,
		30% of farmers/pastorals adopted smart farming system from those farmers/ pastorals who adopted agricultural mechanization technologies		
		10% of farmers/pastorals applied Artificial Intelligence (AI) systems who adopted agricultural mechanization technologies		
5	Financial services and investment	Importers, local manufacturers, farming community, mechanization service providers and other actors get access to credit service	175	NBE, MoF, ECRA, MoA, Investment Commission,
		Importers, local manufacturers, farming community, mechanization service providers and other actors get access to insurance services		
6	Agricultural mechanization technologies manufacturing and assembly plants	Manufacturers and assembly plants strengthened and established by foreign and local investors	147	MoA, BoA, MoLS, Investment Commission,
		Ensure quality assurance of agricultural machinery technologies manufactured, assembled and imported.		

No	Pillars	Expected outputs	Budget (USD in Million)	Responsibility
7	Crosscutting issues in agricultural mechanization	50% women, youth and people with special needs participated in agricultural mechanization initiatives,	91	MoA, BoA, MoTL, MoWS, MoIL, MoWE, EEA, ERA, EPA, EBI,
		Fully food and nutrition mainstreamed mechanization technology development and popularization,		
		50% reduced CO2 emission in the use of fuel agricultural mechanization technologies		
		Disposal system created for scraped agricultural mechanization technologies		
		Put in place safe use and disposal for used/burned oil and lubricants applied agricultural machineries		
		Improved awareness on sustainable use of biophysical environment in use of mechanization technologies		
		Expanded harmonized rural infrastructure and irrigation system for agricultural mechanization technologies.		
Total			**698.6**	

Communication and socialization strategy: It is true that effective communication and socialization of agricultural mechanization strategy are essential for ensuring successful implementation by participating the entire stakeholders. In this endeavor, a separate communication and socialization plan shall be developed by considering all relevant stakeholders including farmers/pastorals, public and private organizations, NGOs, community groups, rural women and youth, people with special needs, etc. Once the strategy officially launched, a sensitization and awareness campaign shall be organized to inform the public and stakeholders about the strategy and its ultimate impact of agricultural mechanization in agricultural development activities. For effective two-way communication, feedback mechanism shall be put in place to collect feedbacks and areas of improvements. Furthermore, several communication materials shall be developed on success stories and disseminated for wider scaling out and up. The public communication executive office in the Ministry of Agriculture will develop a communication plan for the NAMS. This office shall facilitate communication through different public, private and social media platforms to smallholder farmers and all relevant stakeholders in the sector to ensure the agricultural mechanization messages intended for the various target audience.

PART SIX
MONITORING, EVALUATION, AND LEARNING

For realizing impactful results of the National Agricultural Mechanization Strategy (NAMS), an independent implementation plan should be prepared. On the basis of this plan, the implementation of the NAMS will be monitored regularly by the NAMSC and the NAMTC. The progress report shall be presented by the mechanization department of the MoA as per the annual reporting framework, which shall be prepared separately. Evaluation shall also be conducted to assess the impact of the NAMS and benefits accruing to the smallholder farmers, farming community, and transformation of agriculture at large. This will involve the establishment of baseline benchmarks and indicators by the responsible ministries in collaboration with key stakeholders. The NAMS is underpinned by the principles of integration, collaboration, and cooperation with stakeholders, especially the private sector.

Hence, monitoring, evaluation, and impact assessments shall be undertaken through strong partnerships and coordination between government ministries, academic institutions, the private sector, development and cooperating partners, NGOs, and other stakeholders. For effective monitoring and coordination of the NAMS, all key ministries and institutions will align their monitoring and evaluation frameworks with the government-wide Monitoring and Evaluation System. The institutional arrangements for monitoring and evaluation shall mirror the roles and responsibilities set out in the implementation framework of the national implementation plan. This is to ensure that

planning and monitoring and evaluation processes are standardized, interconnected, fully internalized, and applied by the relevant institutions with the view to generate coordinated developmental results to inform decision-making processes.

Monitoring of strategy implementation will be central in ensuring that planned strategic interventions are implemented effectively and efficiently. Regular monitoring should be underway at the national level by the MoA, the NAMSC, and the NAMTC. Monitoring of interventions shall be done by the regional, zonal, and woreda levels by strong support and supervision of the regional bureau of agriculture and Ministry of Agriculture. Technical staff of the mechanization department in the Ministry of Agriculture shall conduct regular field visits to provide technical support to staff at regional, district, and woreda/kebele levels. Sustainable quarterly review meetings shall be held to assess progress towards the achievement of the agreed results. Challenges and duty bearers arising during implementation of NAMS can be resolved expeditiously. Problems that may not be resolved should be presented to NAMSC and NAMTC. Intersectoral and cross-cutting mechanization-related issues are communicated regularly to the high-level MoA.

The Technical Services responsible body shall be required to produce quarterly performance reports in narrative and financial form for analysis and discussion by the ministry through various sector working committees. The quarterly reports will focus on progress made against planned inputs and outcomes, resource use efficiency, review

of performance levels achieved, and proposed measures to improve performance.

Evaluation assesses impact and how well-planned strategic interventions are managed for future outcomes. The strategy is accountable for achieving outcomes and contributing to mechanization development impact. Since the achievement of short- and long-term agricultural mechanization development changes depends on many factors, it is usually not possible to attribute impact to one sector. Building the link to monitoring, evaluations will be conducted mainly to assess the impact of the NAMS in the medium and long term.

Apart from the high-level board of NAMS, regional agricultural mechanization evaluation boards should be established. Board members should be organized from different sectors, which are structured down from the responsible minister, stakeholders, and private individuals in the region. The progress and impact assessment shall be undertaken at the first of the strategic implementation phase so that it becomes a basis for performance and impact assessment in years to come and continues till the strategic year. Evaluation shall be aligned with other performance reporting frameworks so that duty bearers are prepared to conduct a mid-term review and an end-term evaluation at the end of the implementation period. Evaluations (both mid- and end-term) shall provide lessons from assessments of the impact, both intended and unintended, to inform similar interventions in the future aimed at increasing the utilization of appropriate agricultural mechanization technologies and agricultural productivity.

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ANNEX

Annex 1. Role and responsibility of stakeholders

No	Stakeholders	Roles and responsibilities
1	Ministry of Agriculture (MoA)	▪ Prepare implementation plan /roadmap for implementation of the strategy ▪ Allocate human and financial resource for the implementation of the strategy ▪ Support and strengthen training institutions to capacitate and increase professional and technicians ▪ Strengthen mechanization technology extension service ▪ Strengthen technological research and adoption systems ▪ Create systems for technology multiplication and dissemination ▪ Support private and public sector engagement in technology adoption, multiplication, and dissemination ▪ Establish and strengthen mechanization technologies testing and certification center ▪ Prepare and implement mechanization service guideline ▪ Create alignment mechanization structure within federal and regions ▪ Support agricultural mechanization structure at regional levels ▪ Create conducive environment for private sector to import, manufacture and assembly and service provision of mechanization technologies ▪ Develop legal frame work for overall national agricultural mechanization strategy implementation

No	Stakeholders	Roles and responsibilities
2	Ministry of Education (MoE)	▪ Strengthening and development of agricultural engineering programs ▪ Conduct training of mechanization professional (human resource development), & design capacity building program. ▪ Strengthen and support agricultural mechanization technologies research, technology transfer and community service ▪ Strengthen the linkage among university, industry, and other stakeholders (MinT, EIAR and MoA) ▪ Improve Educational curriculum based on market demand
3	Ministry of Labor and Skills (MoLS)	▪ Enhance the capacity of ATVETs to train agro-mechanics and operators to fulfill the demand of skilled manpower in the sector ▪ Introduce new Agricultural Engineering training program at Federal and regional level ▪ Improve training curriculum based on market demand ▪ Support and capacitate private and public training institutions ▪ Support youth groups and women through Agricultural mechanization Technology Entrepreneurship's skills training
4	Ministry of Planning	▪ Provide leadership and technical support in conducting, organizing, and planning the National Agricultural Mechanization Plan. ▪ Ensure cross-sectoral alignment between mechanization initiatives and national development priorities. ▪ Facilitate inclusive stakeholder participation, integrating regional, gender, and youth perspectives into planning processes.

No	Stakeholders	Roles and responsibilities
5	Ministry of Revenue (MoR)	▪ Facilitate the design and execution of fiscal and tax-related incentives that strengthen domestic agricultural machinery production. ▪ Ensure policies encourage investment, service expansion, and equitable access to machinery across the sector. ▪ Support the development of incentive frameworks for importers, service providers, and manufacturers engaged in agricultural mechanization.
6	Ministry of Finance (MoF)	▪ Introduce new incentive mechanism to support private sectors engaged in multiplication, import, dissemination, and service provision ▪ Sustain existing tax and VAT exception policies for agricultural mechanization technologies ▪ Support agricultural mechanization fund, allocate finance for the implementation of strategy. ▪ Establish and administer Mechanization technology Fund
7	Ministry of Lowland and Irrigation (MoLI)	▪ Expand irrigation infrastructure suitable for mechanization technology utilization ▪ Introduce smart irrigation technologies (Precision agriculture and climate smart technology) ▪ Support irrigated agriculture service providers ▪ Introduce and promote mechanization technologies for pastoralists
8	Ministry of Innovation & Technology	▪ Support mechanization innovation and digital agriculture ▪ Strengthen collaboration between higher learning and Research Institute
9	Ministry of Industry	▪ Support and strengthen small- and large-scale local manufacturing industry ▪ Strengthen and expand collaboration with multi-stakeholders working on agricultural mechanization technologies ▪ Promote agricultural mechanization technology multiplication and commercialization ▪ Establish standardize mechanization technology manufacturing center

No	Stakeholders	Roles and responsibilities
10	Ministry of Water and Energy	▪ Construct and expand irrigation infrastructures in agricultural production ▪ Strengthen renewable alternative energy source
11	Ministry of Trade and regional integration	▪ Enhance the usage of mechanization technologies in the effective and accessibility of services
12	Ethiopian Agricultural Authority (EAA)	▪ Provide technical, strengthen, and control mechanization technologies for implementation of testing and certification center ▪ standard and regulate mechanization technologies usage and services ▪ Establish regulation and directives for mechanization technologies service provision ▪ Strengthen monitoring and control of agricultural mechanization quality generation and multiplication
13	Ethiopian Agricultural Research Institute (EIAR)	▪ Strengthen technology generation, adaption, and adoption capacity of agricultural engineering/ mechanization research centers ▪ Generate appropriate scale mechanization technology for small and medium farmers. ▪ Support private sectors and organized youth groups in technology multiplication and dissemination ▪ Working with higher learning and technology Innovation institutions to build the capacity of researchers and innovators ▪ Working collaboratively with small- and large-scale agricultural mechanization manufacturing industries ▪ Conduct technology demonstration and suitability test across agro ecologies and farming system

No	Stakeholders	Roles and responsibilities
14	Ethiopian Federal Cooperative Commission	▪ Establish robust systems in cooperative union for agricultural mechanization service provision ▪ Build capacity of mechanization service centers both in man power and facilities ▪ Establish fair and inclusive services of mechanization for farming community ▪ Developing guidelines and legal measures that are consistent with the Ministry of Agriculture policy in mechanization services and technology usage. ▪ Support regional cooperative in the establishment of agricultural mechanization service provision and work on mechanization technology accessibility and service price regulation
15	Ethiopian Coffee and Tea Authority	▪ Support, strengthen and empower the development agricultural mechanization technologies for Coffee, Tea and Spice productivity ▪ Work with MoA to Strengthening and support small and large-scale coffee, tea and spice processing industry.
16	Agricultural Transformation Institute (ATI)	▪ Supports regional governments to develop agricultural mechanization value chains in geographic clusters ▪ Provides technical implementation support in area of agricultural mechanization technologies
17	National Bank of Ethiopia (NB)	▪ Prepare legal frameworks to establish Agricultural mechanization fund ▪ Create conducive environment for the establishment of National Agricultural Bank to sustain financial supply to the sector ▪ Provide special support for private sectors to access forex to import agricultural mechanization technologies
18	Agricultural mechanization Service providers (private, cooperative union)	▪ Provide feasible mechanization service to improve efficiency and productivity along agricultural value chain ▪ Introduce and promote digital service provision ▪ Provide awareness for service utilizers to expand their accessibility ▪ Deliver quality service, provide services timely with fair price ▪ Provide alternative and appropriate technologies for small and medium land holders' farmers

No	Stakeholders	Roles and responsibilities
19	Agro-processing industries	▪ Utilize improved technologies to improve their productivity, quality, and safety of their products ▪ Strengthen collaboration with agricultural products producer (Farmer and Investor)
20	Financial institutions	▪ Provide loan at feasible interest rate along mechanization value chain ▪ Expand their accessibility along agro ecology and production system ▪ Support farming community by allocating credit facilities to support strategy implementation
21	Ethiopian Agricultural Engineering Society	▪ Conduct Research on the utilization of agricultural mechanization technologies and service provision ▪ Generate policy issues/idea to improve innovation capacity, adoption, multiplication, and dissemination of mechanization technologies ▪ Engage in capacity building for professionals, service providers and technology utilizers ▪ Support the government to introduce digital agriculture, precision agriculture and AI application in the sector ▪ Engage on Agricultural Engineering curriculum development with higher education
22	Ethiopian Custom Commission	▪ Support and managing customs operations, taxation, and international trade compliance on Agricultural mechanization in Ethiopia ▪ Support on agricultural machinery clearance and data of agricultural machinery imported to Ethiopia
23	Agricultural machinery manufacturers	▪ Multiplying adopted and invented technologies approved by research and other related institutions ▪ Assemble and manufacture imported mechanization technologies based on market demand ▪ Improve supply of mechanization technologies with competitive price
24	Ethiopian Standard Authority	▪ Improve the development of machinery and service standards
25	Ethiopian Telecommunication Enterprise	▪ Develop and expand network infrastructure, support digital agriculture and IT infrastructure development

No	Stakeholders	Roles and responsibilities
26	Ethiopia road Authority	▪ Develop and expand rural road and bridge infrastructure, enact road transport regulation for farm machinery and support maintenance of rural access road.
27	Ethiopian electric power authority	▪ Support rural electrification and ensure sustainability of electric supply for agricultural productivity and processing.
28	Regional Agricultural Bureaus	▪ Lead and implement national agricultural mechanization strategy in their respective regions ▪ Strengthen collaboration with multistakeholder working on agricultural mechanization technologies service provision, generation, and multiplications ▪ Introduce and expand new technology, facilities, and systems of agricultural mechanization technologies implementations ▪ Put in place dedicated agricultural mechanization structure with mechanization professionals, including a unit for mechanization extension ▪ Strengthen and support agricultural mechanization associations
29	Non-government and Development partners	▪ Support the implementation of the strategy financially, cooperate in capacity building programs at all levels ▪ Support the implementation of the strategy financially and technically

Annex 2. Risks and response strategies

Risk Areas	Risk Statement	Likelihood	Risk Sources	Response Strategy
Initial Capital and Investment	Shortage of forex, high initial costs for manufacturing and importation of technologies & machineries'	High	Limited availability access of forex, financing options and high-interest rates from banks.	Establish Supplier credit with manufacturers, government subsidy, government grants and low-interest loans specifically for smallholder farmers, service providers, to facilitate access to agricultural machinery.
Financial Services	Machinery manufacturers importers, farmers low access to get financial service including (loan and credit) for Agricultural mechanization.	Medium	Lack of agricultural banks and financial institutions for farmers and limited investment opportunities.	Establish agricultural banks work with others banks & microfinance institutions
Knowledge and Skill	Insufficient Knowledge, Attitude, and skill (KAP) on modern agricultural technologies manufacturing, testing, operation, and maintenance.	Medium	Limited agricultural extension services and training programs available to agricultural mechanization value chain actors.	Expand training programs through collaboration with higher learning institutions, NGOs & overseas experience sharing visit to enhance skills in machinery operation, testing, maintenance, and modern farming techniques.

Risk Areas	Risk Statement	Likelihood	Risk Sources	Response Strategy
Facilities and Infrastructure	Poor infrastructure hampers the usage, mobility, distribution, and maintenance of agricultural machinery	Medium	Inadequate electric supply, fuel stations, rural roads and service centers limit access for technologies and services	Invest in rural infrastructure improvements, including road construction and establishment of local service centers for machinery maintenance and support.
Employment and Job Opportunity	Due to increased mechanization could lead to job losses in traditional farming roles.	Medium	Mechanized farming may displace existing unskilled labors	Implement training programs for displaced workers, focusing on new roles in machinery operation, maintenance, and other agricultural services to ensure employment continuity.
Environment	Mechanization may exacerbate environmental issues such as (soil compaction, degradation, air pollution and others) if not properly managed.	Medium	Improper utilization of machinery can lead to soil degradation and increased carbon emissions.	establish quality testing and safety certification system alongside mechanization.
Health and Safety	Heavy machinery poses safety risks for operators, mechanics, farmers without proper training.	Medium	Lack of safety protocols and training leads to accidents on farms using machineries and equipment.	Mandate safety training programs for all machinery operators, coupled with regular safety inspections of equipment used in the field to ensure compliance with safety standards.

Risk Areas	Risk Statement	Likelihood	Risk Sources	Response Strategy
Conflict and Security	insecure environment leads to hampers the manufacturing, distribution, and machinery service for farmers discourage local & foreign investors engagement in the sector.	High	Political instability	Work with national local government to create peaceful working environment

Annex 3. Major company contributed for tractor import for the last 10 years

No	Company name	Quantity of Machinery Imported/ Sold												
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
1	Kegna Machinery company	0	0	0	0	73	354	310	1000	500	0	862	861	3960
2	Woreta Machinery company	0	0	0	0	0	62	132	285	87	103	150	0	819
3	Ethiopia Agr. Business Corp.	0	0	0	11	16	22	4	8	58	55	0	0	174
4	Moenco	30	51	51	81	47	37	64	49	27	35	0	41	513
5	Kaleb Farmers house	4	19	14	6	3	32	1	0	0	0			79
6	Ries Engineering	66	68	33	63	66	54	36	34	44	0	0	82	546
7	Hagbes	9	9	1	1	28	14	20	11	9	9	0	0	111
8	Gadeb Engineering	63	25	13	15	4	14	0	0	0	0	0	0	134
9	Adab Engineering	50	21	59	26	44	06	0	0	0	0	0	0	0
10	Adama Agri. Machinery Industry	50	802	0	0	0	0	0	0	0	0	118	0	206
Total														**6542**

Annex 4. Major company contributed for combine harvester import for the last 10 years

No	Company name	Year of import/sold and quantity of machinery										
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
1	Kegna	0	0	0	0	0	0	80	0	0	0	80
2	Woreta	0	0	0	0	0	0	3	12	9	0	24
4	Ethiopia Agr.B.Co	0	0	0	0	0	0	0	0	0	23	23
5	Moenco	9	16	17	47	1	49	109	4	29	23	304
6	Kaleb	11	46	24	42	12	50	88	14	16	7	310
8	Hagbes	0	0	0	0	0	0	6	0	0	0	6
9	Amio Engineering	0	110	8	6	8	0	0	0	0	0	32
	Total	20	62	49	95	21	99	286	30	54	53	779

Annex 5. Type and scale of Mechanization Technology

S.N.	Small Scale Mechanization Technology	Medium Scale Mechanization Technology	Large scale mechanization Technology
1	Drinker (Waterer) for poultry production	Autoclave for fish can sterilize	Automatic chaff cutter
2	Feeder for poultry production	Automatic fish feeders	Automatic Milk Chiller
3	Chicken Laying Nest	Automized Incubator	Automized incubator
4	Bee Sprayers	Cassava cultivator	Blast freezer for fish freezing
5	Burdizo for PTC, FTC, and commercial feedlots	Chicken Scalder	Boom sprayers
6	Casting Molds	Chicken Scalder	Carrot planter
7	Chick Guard (Brooder Guard)	Coffee cultivator	Cassava piller
8	Egg Tray	Coffee processing machine	Coffee harvester
9	Electric/ motorized Chopper	Coffee De-huller	Cold storage for fruit and vegetable
10	Electrical Foundation Sheet Printers	Different thickness multifilament Fishing net twines	Crop Quest for commercial feedlots
11	Electrical Wax Processors	Inset decorticator	Drip Irrigation Systems
12	Fish handling boxes	Inset fermenter	Drying machines

S.N.	Small Scale Mechanization Technology	Medium Scale Mechanization Technology	Large scale mechanization Technology
13	Glove (for artificial insemination)	Extrusion cooker with different die size	Electric generators
14	Hive Tools (Queen Excluders)	Fruit and vegetables planter	Feed mixer
15	Honey Extractors	Fruit and vegetables cold chain truck	Fish cold storage
16	Honey Pressers	Fruit and vegetables Harvester	Fish cutting machines
17	Honey Processing Machines	Fruit and vegetables transportation truck	Fish feed Pressing machines
18	Hoof trimming for PTC, FTC commercial feedlots	Fruits and vegetables crate	Fish hatchery Hapas
19	Ice boxes	Ground nut digger	Fruit and vegetables cold storage
20	Improved & Modern bee hives	Honey Extractors	Fruit and vegetables cold chain truck
21	knapsack sprayers	Improved & Modern bee hives	Fruit and vegetables Harvester
22	Lactometer	Indoor Fish hatchery full equipment	GPS attached on tractor and combiner
23	Lacto-scan	Insect killer device	Hatchery Tilapia Fish cage nets
24	Laying Nest	Milk cream separator	Improved & Modern bee hives
25	Manual /Electrical debeaker	Mini cultivator	Maize combiner harvester
26	Manual butter churner	Mini multi crop harvester	Milk storage equipment
27	manual chopper	Mini tractor	Milk Transportation Truck

S.N.	Small Scale Mechanization Technology	Medium Scale Mechanization Technology	Large scale mechanization Technology
28	Manual Cream separator	Motorized /Electric chopper	Oxygen supplier cylinder
29	Manual maize sheller	Motorized Teff thresher	Packing machines
30	Manual milking machine	Motorized/electric/solar milk churner	Palm date processing machine
31	Metal silo	Motorized/tractor mounted crop thresher	Pelletizer machine
32	Milk can 20lit	Multimeter for measuring Aquaculture water quality	Planted lime crusher
33	Milk can 50lit	Onion digger	Potato planter
34	PICS bags	Onion harvester	Refrigerator truck for fish transportation
35	Pollen Traps	Onion planter	Rice de-husker
36	poultry cage system	Potato digger	Rice polisher
37	Poultry Drinker (Waterer)	Poultry Drinker (Waterer)	Rice transplanter
38	Poultry Feeder	Rice transplanter	Row planter and transplanting machinery
39	Reflector/Hovers	Row planter and transplanting machinery	Sesame seeder

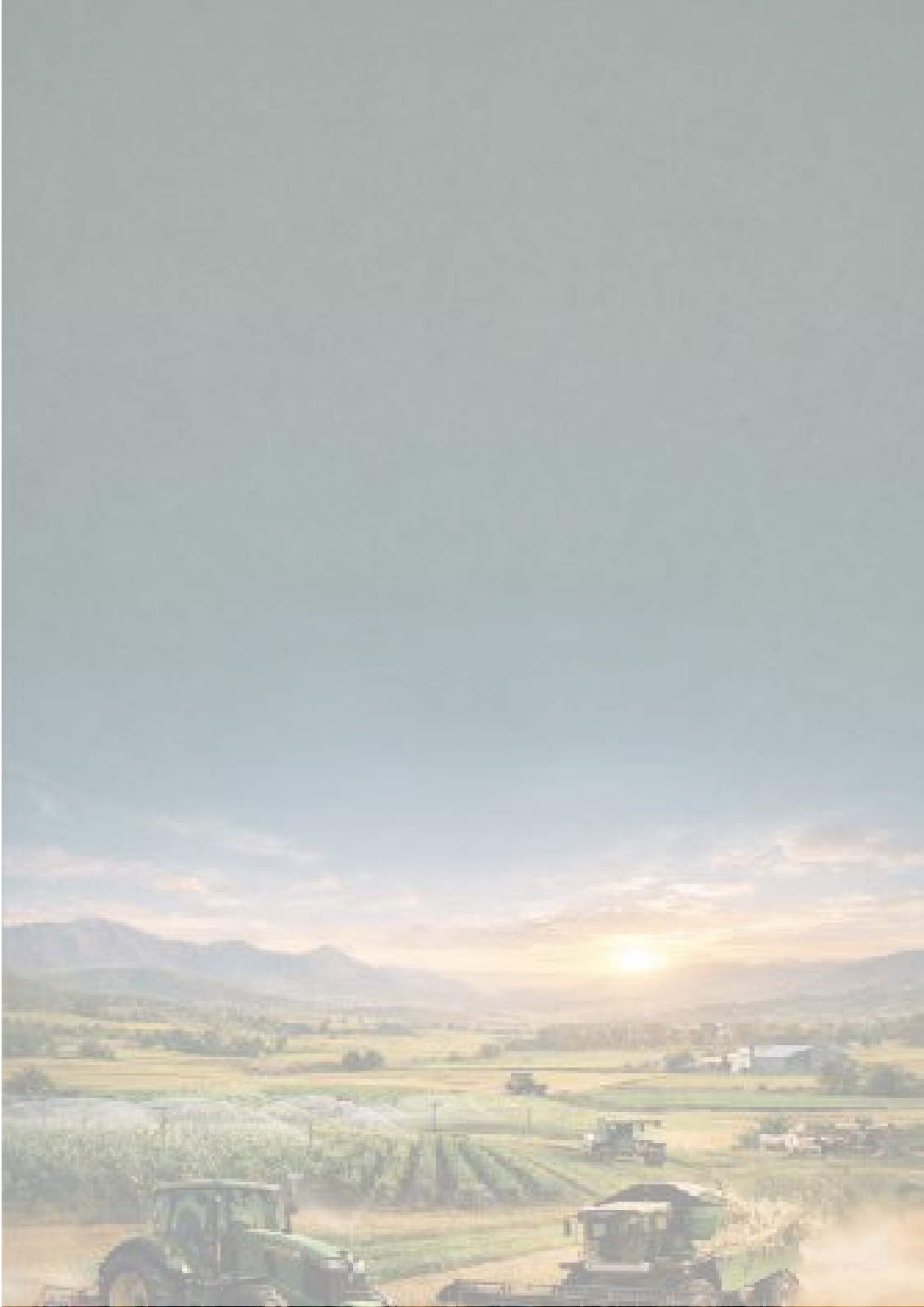
S.N.	Small Scale Mechanization Technology	Medium Scale Mechanization Technology	Large scale mechanization Technology
40	Scoop nets	Tractor from 50hp up to 100 hp	Solar-Powered Irrigation Systems
41	Solar Wax Melters		Stainless steel/Aluminum fish processing table
42	Water Sprayers for livestock		Tractor for forage land development
			Unmanned automized sprayer

Steering committee member

No	Name	Position	Organization
1	H.E. Addisu Arega	Minister, Ministry of Agriculture	
2	H.E. Dr. Sofiya Kassa	State Minister for Agricultural Investment and Input Supply Development Sector	MoA
3	H.E. Dr. Meles Mekonen	State Minister for Agriculture and Horticulture Development Sector	MoA
4	H.E. Dr. Fikru Regassa	State Minister for Livestock and Fish Development Sector	MoA
5	H.E. Prof Eyasu Elias	State Minister for Natural Resource Development Sector	MoA
6	H.E. Dr. Mandefro Nigussie	CEO, Ethiopian Institute of Agricultural Transformation	ATI
7	Dr. Tesfaye Mengiste	Policy and Strategy Study and Research LEO	MoA

Technical team member

No	Name of technical team	Position	Organization
1	Ato Aberra Lemma	Adviser, The State Minister of Investment, and Input Sector	MoA
2	Ato Eshetu Hunde	Agricultural Mechanization Expert	MoA
3	Dr. Fisseha Zegeye	Senior Researcher and Policy Advisor	MoA
4	Dr. Amana Wako	Agricultural Mechanization Advisor	MoA
5	Eng. Tamiru Habte	Agricultural Mechanization Advisor	MoA
6	Eng. Birhanu Kebede	Agricultural Mechanization Desk Head	MoA
7	Eng. Wondiye Gezahegn	Agricultural Mechanization Specialist	MoA
8	Ato Tamiru Dibaba	Agricultural Mechanization Research Director	EIAR
9	Ato Zewdu Ayalew	Agricultural Mechanization Project Expert	ATI
10	Ato Sewenet Kidane	Livestock Sector, Senior Expert	MoA
11	Ato Kidane Menkore	Crop Sector, Senior Expert	MoA



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