

Agricultural Mechanization Strategies for Rwanda

Shifting from Subsistence Agriculture to Market-oriented
Agriculture

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Executive Summary

Farming in Rwanda remains largely subsistence in nature. With a rapid increase in population, the pressure on ensuring food security is a constant challenge for the stakeholders. Significant progress has been made in Rwanda in the past decade with regard to overall agricultural production. However, operational efficiency and farm productivity, and, therefore, the prosperity of a very large proportion of the rural population, continue to be a concern.

As the share of service sector on national economy grows larger, the government seeks to transform farming into a productive, high value, market oriented sector by modernizing 50% of its agriculture by 2020, and thereby improve livelihoods of rural population, achieve food security and increase exports of agricultural products as reflected in the millennium development goals (MDG) and New Partnership for Africa's Development (NEPAD).

Food security shall be enhanced by improving crop productivity and by enhancing area under cultivation of food crops. The major limitation on the already cultivated area is the heavy reliance on the hand hoe used by the human labor. Women workers contribute 77% of those field operations that are carried out by farm families in Rwanda. Increase in labor productivity shall not only increase the overall productivity, but also quickly make the hitherto uncultivated lands available for cultivation. Experience from Asia, Latin America and in some African countries show that labor productivity shall be greatly enhanced by using alternate farm powers such as motorized engines and draught animals.

Mechanization, along with other farm inputs such as fertilizers, improved seeds and pesticides, can significantly improve agricultural productivity in Rwanda. Mechanization is a powerful tool in achieving sustainable agricultural production because it enhances human capacity with the potential beneficiaries being men and women farmers. It allows timeliness, efficiency and consistency in field operations. This is critical for land preparation especially in Rwanda where there is sequential cropping owing to the receipt of rainfall through two seasons a year in most parts of the country.

Farm mechanization can help perform the power-intensive and ergonomically arduous tasks. It can also relieve the growing seasonal labor constraints that are experienced by farmers in several parts of the country. It also helps compensate for the emigration of rural youth who are disenchanted with the drudgery involved in agriculture. Thus mechanization, contrary to the restricted opinion on labor displacement, stands to compliment human labor in improving agriculture production in Rwanda.

Tractors, power tillers and animal traction can also facilitate other off-the-farm tasks such as transportation, driving pumps and agro-processing equipment, maintenance of farm, and rural infrastructure. It is therefore important that farm mechanization should represent a key strategy in raising agricultural productivity and thereby national economy of Rwanda.

Strategies formulated in this document envisions that 25% of farm operations will become mechanized by 2015, allowing one in every 4 Rwandan farmers to either own and/or hire mechanization services in their farm. Enabling access to the various farm mechanization options, development of technical ability and knowledge on farm machineries and implements, and improved agro-processing through mechanization will serve as the key drivers in this transformation.

The requirements of farm power (mostly in the forms of power tiller, tractor and draught animals) shall be initially made available in the country by the government. After the initial wave of investments, the government shall gradually withdraw and hand over to the private sector. The government shall nevertheless continue to remain as a catalyst in sustaining mechanization in the country. It is noted that irrigation equipments such as diesel engines and pumps shall serve as a primer in raising the adoption rate of new farm power, especially in smallholder farms.

Providing access to credit to farmers who would not otherwise be able to adopt mechanization options is critical in providing the transformation. Here it will be important to help farmers' co-operatives leverage their collective bargaining power by assisting in establishing business plan, financial integrity and wherever applicable guarantee loans. Farmers and potential entrepreneurs need to be aware that besides the profitability in using and providing (hire) mechanization services in the farm, machineries such as tractor and power tillers can also be used in generating additional revenues through off-farm activities such as transport and infrastructure development. Building a strong private sector on farm mechanization will create demand and sustenance of the supply of farm power, implements and spare parts.

Technical skills need to be developed at grass-root levels involving rural artisans, operators, mechanic, service providers, farmers and other end-users. Development of agriculture engineering sector in the country will enable creation of new designs of ergonomic tools for human labor and draught animals, and further widen the choice of mechanization options for local conditions. Mechanization options that help conserve natural resources such as land, soil fertility and water need to be developed and endorsed. Rwanda needs a massive adoption program on mechanization delivering knowledge and awareness amongst farmers through potential entrepreneurs and extension agents.

The transformation from subsistence agriculture to commercial agriculture requires integration of mechanization options in commodity chains. By enhancing the quality, value and therefore the marketability of farm produces, the introduction of mechanization in commodity chain will substantially improve the profitability of the farmers. This would provide the much needed sustenance in the envisioned shift from subsistence to market-oriented agriculture in Rwanda. Farmers and potential entrepreneurs need to be educated and trained on the various avenues of mechanization in post harvest handling, storage, and primary- and secondary agro processing enterprises. Linkages along the continuum of production, processing and marketing need to be strengthened through incentives and entrepreneurial spirits. Introduction of mechanization at various stages of processing will not only improve the agricultural commodity chains but also enhance rural employment opportunities and livelihoods in Rwanda.

1. Background

Agriculture is an important pillar of Rwandan economy. In 2009, the agricultural sector which grew by 8%, contributed 34% of national GDP in real terms¹. The estimated population of Rwanda in 2009 is 10,185,435. FAO estimates that the population will rise further to 14 million by 2020². Rwanda faces serious challenges in ensuring food security for its growing population from its limited cultivable terrain.

Rwanda grows a range of agricultural crops over a cultivated area of 1, 205,090 Ha³. The major food crops grown include maize, rice, cassava, banana (cooking, beer and fruit), sweet potato, Irish potato, maize, sorghum, beans. Coffee, tea and sugarcane are the major cash crops. Vegetables such as dodo, gourds, eggplants, onions and cabbages are also widely grown. The relative changes in production of major food crops over the past 4 years are shown in Fig. 1.

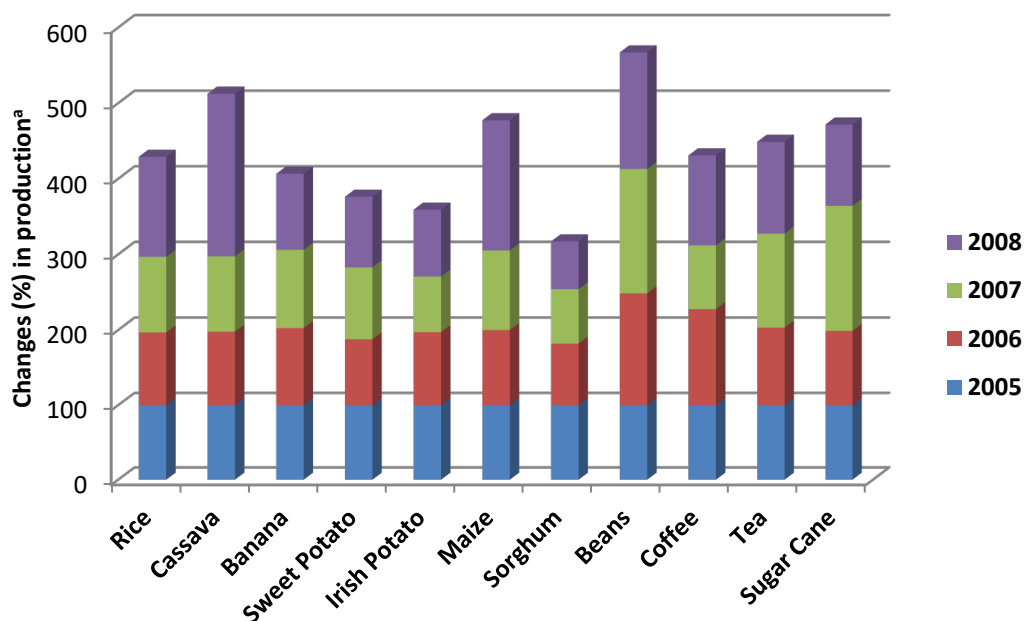


Fig.1. Recent trends in production of major food- and cash crops in Rwanda. The changes are shown in percentages. ^a Normalized to levels of base year production in 2005.

The increase in production in food crops in 2008 is mainly due to a parallel increase in area under cultivation (Table 1).

Table.1. Area under crop production in Rwanda.

Year	2005	2006	2007	2008
Total Arable land ('000 Hectare)	2294.38	2294.38	2294.38	2294.38
Total cultivated Area ('000 Hectare)	852.26	868.31	846.42	1205.09

¹ Press release, 26 March 2010, National Institute of Statistics of Rwanda

² Country Report – Rwanda (2005), Food and Agriculture Organization (FAO)

³Rwanda Statistical Year Book (2009), National Institute of Statistics of Rwanda

About 84% of the total Rwandan population is dependent on agriculture, of which majority (52%) are women⁴. A significant proportion of the agricultural population (42.2%) receives help from family help for their field operations. In such cases, the females constituted 77.2% of help⁴. This shows the importance of the role played by women in the handling of farm operations.

Agricultural mechanization is generally used to achieve results well beyond the capacity of human labor. It refers to application of mechanical power and technology in farm operations. Mechanization includes, but not restricted to, the use of tractors. It shall also include animal-, human-, solar-, electric- and fuel-powered energy conversions. Hence mechanization is often recognized as a means to enhance productivity of human labor in farming. Besides field operations, mechanization can be used in irrigation systems, transport, food processing and related technologies and equipment.

In several developing countries in Asia and Latin America, agricultural mechanization has made significant contributions to agricultural and rural development. Levels of production have increased, soil and water conservation measures constructed, the profitability of farming improved, the quality of rural life enhanced, and developments in the industrial and service sectors stimulated. However, until recently, mechanization efforts have stalled in Rwanda due to social disruptions in the past and the subsequent realignment of priorities. In the current context however, agricultural mechanization has become more important due to the following reasons;

- Food security: To improve food security for its growing population, the country needs to enhance its total food production. The country needs to increase its food production by increasing the area under production and by raising the productivity levels of existing lands. This requires cultivation in hitherto unutilized lands and marginal lands where there is a need for increased labor productivity.
- Urban migration: The changing lifestyles, raising incomes from non-agricultural activities and the subsequent trends in urban migration pose challenges in long term sustainability of growth in agricultural production. The general belief that agriculture and even potential commercial farm activities involves hard physical labor and drudgery further worsens the disenchantment amongst the rural youth.
- Seasonal labor constraints: The nature of farming in Rwanda, with multiple cropping systems, increases the need for rapid land preparation and reduction in turnaround time between crops. Hence labour shortages are becoming a new trend during peak seasons, especially in areas of concentrated production such as the wet and marshlands.
- Drudgery: The excessive reliance of Rwandan farmers on human muscle, and in many cases, aged women's muscle for the arduous tasks in farming poses serious threat on productivity and the long term sustainability of growth in agricultural production.
- Water scarcity: The climatic change and the recent drives in crop intensification require efficient management and equitable distribution of water amongst farming community. Machineries such as pumps, diesel engines and related equipments shall facilitate equitable access to water, especially for small holder farmers.

⁴ National Agricultural Survey (2008) National Institute of Statistics of Rwanda

- Delicate commodity chain: In a globalized scenario, a key question is whether Rwandan farmers will be able to compete with existing gaps in commodity chain. The locally produced commodities generally (rice for instance) suffer from poor marketability. In most instances, this is due to lack of transportation and/or inept processing. Appropriate mechanization in agro processing and value addition can help increase profitability of farmers and improve rural livelihoods by generating employment opportunities.

The arguments against agricultural mechanization such as displacement of labor and the small and fragmented nature of land holdings are often due to a restricted perception that agricultural mechanization involves only the use of tractors. This is one of the fundamental dragging factors for the low levels of mechanization in Sub Saharan Africa^{5,6}. Use of improved hand tools and animal-powered technology by small- and medium-scale farmers should be seen as an integral part of farm mechanization. Those countries that have weathered the negative perceptions in their early years of adoption (such as India, China, Brazil) are now reaping the benefits of mechanization through increase in labor productivity, increase in land productivity, and decrease in cost of production.

Unlike the other farm inputs such as seeds, fertilizers, mechanization represents a long-term investment. Therefore, farm mechanization should generally be recognized as part of a broad-based economic development strategy for national agriculture, where the short-term impacts of mechanization become less significant⁷. Nevertheless, it is acknowledged here that care should be taken to ensure tandem movements of technological, cultural, economical and social development in order to reduce any socioeconomic consequences of mechanization and to enable well-balanced adoption of mechanization in Rwanda.

It is therefore imperative to create a policy, institutional and market environment in which farmers and other end-users in Rwanda have the appropriate choices of farm power and equipment within a sustainable delivery and support system. This forms the objective of formulating mechanization strategy.

2. National Context

Agricultural mechanization initiatives of the Ministry of Agriculture and Animal Resources are coherent with rural development policies and are in consistence with major development orientations envisaged at the national and international level.

2.1. Vision 2020

Government of Rwanda aspires to fundamentally transform Rwanda into a middle income economy (with a per capita income of 900 USD), reduce the people living below poverty line to 30%, and raise the average life expectancy to 55 years by the year 2020.

⁵ Kienzle J, Cuevas R, Wall G (2006) Addressing the challenges facing agricultural mechanization input supply and farm product processing. Proceedings of an FAO workshop - Germany.

⁶ Mrema, G. C., Baker D. and Kahan, D (2008) Agricultural Mechanization in Sub-Saharan Africa: Time for a new look, FAO, Rome

⁷ Rijk, A.G. 1989. Agriculture Mechanization Policy and Strategy. Asian Productivity Organization, Tokyo

To realize this vision, the government seeks to transform agriculture into a productive, high value, market oriented sector, with forward linkages to other sectors. Vision 2020 aims to modernize 50% of its agricultural land by 2020. Experience in other African countries (such as Ethiopia, Nigeria, South Africa, and Zambia) and in other developing economies of Asia and Latin America show that mechanization has transformed agriculture in recent years into a modern, progressive commercial activity. Agricultural mechanization in these countries has enabled farmers to intensify production and improve their quality of life as well as contributing to rural prosperity. Much the same could happen in Rwanda, if farmers and other end users in agriculture are provided with suitable options of mechanization.

Vision 2020 acknowledges that Rwandans can no longer subsist on land. The government recognizes the need, instead, to devise ways and means to move the population and economy from its dependence on agriculture into the secondary and tertiary sectors. Mechanization can help attenuate labor constraints and thereby allow farm- and farm dependent families to devote more time on off-farm activities, earn additional incomes, and expand their livelihood strategies. Even in areas that are heavily reliant on crop farming, significant remuneration can be made from non-farm employment such as in small scale agro-processing industries, trading and brick-making, and thus can indirectly promote activities in other sectors.

Vision 2020 also seeks to develop an efficient private sector in all sectors and expects it to be driven by the spirits of competitiveness and entrepreneurship. Rwanda have entrepreneurs/farmers who are ready to invest in draught animals, machinery and implements for use on their farms as well as for providing mechanization services to the small-scale farmers who are unable to gather such levels of capital investments. If the tractor and irrigation markets could be expanded, the opportunities for manufacturing and/or assembling industry would also open up in Rwanda. Furthermore, mechanization can also prompt development of small-scale agro-processing industries. Thus, agricultural mechanization is consistent with the long term strategies of Rwanda.

2.2. Economic Development and Poverty Reduction Strategies (EDPRS)

EDPRS, the medium term strategy for 2008-2012 developed by the Government of Rwanda, seeks to increase economic growth through modernization of agriculture. The productive expenditures under EDPRS aims to (i) address skills shortages and (ii) modernize the agriculture.

EDPRS acknowledges that the low level of agricultural productivity in Rwanda is due to the low level of agricultural technology. EDPRS also intends to assign a greater role in policy implementation to markets and the private sector. To promote commodity chains and support the development of agribusiness, EDPRS intends to subsidize the acquisition of key inputs by farmers' cooperatives. Under EDPRS, public investments are being directed into the construction and rehabilitation of feeder roads. It aims to reduce the employment in agriculture (% reporting as main occupation) to 70% by 2012 (from 80% in 2007).

Agricultural mechanization can act as a catalyst in all of these main programs – By reducing/eliminating the fallow period and promote crop sequencing, by minimizing the time for

field operations, the farmers can find more time to improve their technical capabilities in agricultural production and by improving the quality of production commodity chains can be strengthened, by encouraging the private sector and entrepreneurship, rural financial markets can be developed and the supply of agricultural credit from private and/or public sources to both men and women can be improved.

2.3. National Agriculture Policy

National Agricultural Policy (NAP) developed by Ministry of Agriculture and Animal Resource envisions modern, professional, innovative and specialized agriculture for Rwanda. Having acknowledged that agricultural mechanization is nearly absent in the country, the NAP sets modernization of agricultural production through development of animal traction farming and agricultural machineries suitable to the real conditions as one of the specific objectives. NAP also envisages development of motorization adapted to steep gradient of the country, and post-harvest technologies.

2.4. Strategic Plan for the Transformation of Agriculture in Rwanda – Phase II (PSTAI)

PSTAI which outlines MINAGRI's activities has developed agendas for intensification and development of sustainable production systems under its mainstream programs. Under Program 1, the strategic plan intends to promote the use of farm mechanisation in appropriate forms, along with animal traction. The sub-program 1.5.2 intends to inform farmers of appropriately scaled mechanisation options and offer training and access to finance to local entrepreneurs who wish to acquire tractors and other machinery and rent the machinery or sell mechanisation services to farmers. It intends to explore the opportunities for (i) adopting animal traction need as they are environmentally and economically more appropriate and (ii) options such as small tillers, of the kind used in East Asia.

3. Regional/Global Context

The national issues related to agricultural revitalization and its implications on national economic development are reflected also in the Millennium Development Goals (MDG). Under MDG, one of the approaches for development in Rwanda is sustainable agriculture. It also includes food security, quality improvement and competitiveness. MDG envisages improvement of rural livelihood by raising the value of agriculture commodities. MDG emphasizes that increase in food production through development and rehabilitation of irrigation facilities, post harvest mechanization are the proposed strategies.

New Partnership for Africa's Development (NEPAD) makes agriculture one of its main priorities "as the engine of NEPAD inspired growth". It stresses three aspects: improving the livelihoods of people in rural areas; achieving food security; and increasing exports of agricultural products. NEPAD emphasizes that agricultural development should be driven by technologies. NEPAD recommends strategy and policy reforms in promoting modernization and diversification of agricultural production and exports. These aims can be achieved only by giving serious attention to family farm power in small holder farms.

4. Agricultural Mechanization in Rwanda

4.1. Definitions

Agricultural Mechanization: It refers to the use of tools, implements and machines for agricultural land development, crop production, harvesting, and preparation for storage, storage, and on-farm processing. It includes three main power sources: human, animal, and mechanical. The manufacture, distribution, repair, maintenance, management and utilization of agricultural tools, implements and machines is covered under this discipline with regard as to how to supply mechanization inputs to the farmer in an efficient and effective manner.

Agricultural Mechanization Strategy (AMS): It provides outlines or the ways in which mechanization policies are to be implemented. Therefore it involves guidelines on how to create conditions that are conducive to the adoption of appropriate farm tools, implements and machinery in a most effective and efficient way. The output of AMS consists largely of policy and institutional recommendations and reforms. In a dynamic environment, conditions change over time and therefore an AMS will need to be regularly refined, revised and adjusted; an AMS should be dynamic.

Hand tool technology: It represents the simplest and most basic level of agricultural mechanization: the use of tools and simple implements using human muscle as the main power source.

Draught animal technology: It implies implements and machines utilizing animal muscle as the main power source.

Farm power: It involves the application of power to agricultural production from human, animal and mechanical sources.

Agricultural engineering sector: It covers the manufacture, import, distribution, repair and maintenance, and use of agricultural tools, implements, machinery and equipment in association with human, animal or engine power sources. Supporting activities, such as research, education and training, extension, credit, product testing and evaluation, and consumer protection are also addressed.

4.2. Farming Systems in Rwanda

Most of the farmlands in Rwanda consist of fragmented plots of land. The average surface area of farm holding in Rwanda is 0.76 Ha⁴. On an average, the farm holdings are spread over 4 different blocks of lands. Approximately 80% of farms have a surface area of less than 1 Ha each.

Seven types of terrain which influence mechanization options have been identified in Rwanda (Table 2). The eastern province is largely characterized by flat lands and shallow sloped hills. The Northern and Western provinces have steep sloped hills. The southern province consists of hills with moderate slopes. All provinces have valleys with either marshlands or wetlands. Terracing is a feature found on moderate to steep hills in the all provinces. The land adjacent to the volcano in Musanze district of the Northern Province is characterized by rocky soils. The seven terrains

identified are steep hills, terraced steep hills, shallow hills, flat dry lands, marshlands, wet lands and volcanic lands.

Table.2: Distribution of terrains

Province	Terrain
Eastern	Flat lands and rolling hills
Southern	Gentle hills with medium slopes, wet lands and Marshlands, terraced lands
Northern	Steep hills, wet lands and marshlands, terraced lands, volcanic lands
Western	Steep hills, wet lands and marshlands, terraced lands

The variability in the distribution of slopes in selected districts of each of the provinces is shown in Table 3. The eastern province has most of its slopes between 0 and 16%. This terrain is suitable for use of animal- and tractor powers. The southern province have most of the lands in the 6-40% category which makes tractor use risky but allows for two-wheel tractors, animal traction operation. Tractors with greater roll-over angles could also nevertheless be used here. Although the topography is highly variable, the Northern and Western provinces have most of their lands in the 16-40% zone with limited suitability for tractor use. There is also room for animal traction on areas with 0-16% slopes. It should be noted that all four provinces have lands with 0-16% slope and are therefore suitable for tractor use. The wide variations in topography of terrains highlight the need for site specific mechanization options in Rwanda.

Table.3: Distribution of slopes (%) in selected districts of each province

Province	District	Sector	0-6%	6-16%	16-40%	40-60%
East	Bugesera	Nyamata	60.93	38.52	0	0
	Bugesera	Musenyei	64.09	34.83	0	0
North	Burera	Rwerere	9.52	18.69	68.76	3.03
	Burera	Nemba	10.09	16.56	70.23	3.11
South	Kamonyi	Kayenzi	9.61	34.16	58.57	1.79
	Kamonyi	Ngamba	21.32	21.43	43.21	1.3
West	Karongi	Rubengera1	6.05	21.43	70.51	2.01
	Karongi	Rubangano	9.91	28.11	60.78	1.21

4.3. Current Status of Agricultural Mechanization in Rwanda

Most of the field operations in Rwanda are carried out by human labour. Use of hand tools accounts for 98.5% of all land tilled in Rwanda. Use of animal traction or tractors is isolated and does not significantly contribute to agricultural production in Rwanda. Application of animal traction is very limited in Rwanda. Current statistics put the level of use of animals and tractors at 1.4% and 0.1% respectively. In 2008, Rwanda recorded 1,548,521 cattle². Nyagatare district in the Eastern province shows the most signs of animal traction use in the country. The impact of culture, grazing and maintenance requirements of using draft animals in on cost-benefit ratio remains to be studied. Recently MINAGRI imported a total of 66 tractors, 50 power tillers (15 HP), 2 rice transplanters and implements for ploughing and harvesting (potato) from Tong Yong Moolsan (TYM) Inc. South Korea. These machineries are currently being sold to farmers and farmer co-operatives.

Table 5: Current status of agricultural mechanisation

District	Province	Hand tools	Animal draft	Motorized traction
Nyagatare	East	Most farmers	Isolated pockets	Very limited; Some Co-ops own and buy tractors
Ruhango	South	All farmers	None	None
Nyanza	South	All farmers	None	None
Kayonza	East	All farmers	None	None
Bugesera	East	All farmers	None	None
Rulindo	North	All farmers	None	None
Kirehe	East	All farmers	None	None
Gisagara	South	All farmers	None	None
Nyamagaba	South	All farmers	None	None
Kamonyi	South	Most farmers	Isolated (NGO-RAFF)	None
Ruhango	South	All farmers	None	None

The existing level of mechanization inherently perpetuates drudgery and prevents diversification of land use patterns. The low levels of mechanization also restrict the engagement and performance of household tasks, more so by women. The rapidly changing demographic trends such as urban migration, ageing rural population, ageing farmers, and the HIV/AIDS pandemic add more concerns on labor availability.

4.3. Power Supply Chain

4.3.1. Hand Tools

Hand tools such as hoes, picks and shovels are sourced from China. These are imported by the wholesalers in Kigali. Retail outlets in the districts and sector level shops are procuring from the Kigali wholesalers and then selling directly to farmers. Hoes are readily available even in the remote areas at prices ranging from 1300-1500 FRW. The handles are either procured in Kigali or crafted by the farmers from tree branches cut down in their vicinity.

Farmers do not find any constraints in availing the tools from the suppliers. The supply chain is demand- driven and executed by the market. It does not need any support services from the government. Knapsack sprayers are also readily available in hardware shops in Kigali and in district centers all over the country. The sprayers are being sourced from China, India and Brazil.

Human labor, the most common farm power, is generally readily available in the country side. The recent efforts on crop intensification in the country prompt sequential cropping and synchronization of farm activities. Hence seasonal labor constraints and the subsequent increase in cost of production have begun to emerge in areas under intensive cultivation. Depending on the course of season, the minimal daily labor wages can range from 700 FRW/day to 1000 FRW. Such variability in wages during a crop season affects timely operations by small holder farmers.

4.3.2. Animal Draft Inputs

The Rwandese Association for Sustainable Development (ARDI) is the only manufacturer of animal drawn equipment identified in Rwanda. The premises have only some very basic tools such as cultivator and plough with French type tool bar carriers. The quality of such tools is however low. Some of the local non-government organizations (NGO) distribute the products to farmers directly. The demand for such tools is generally low due to limited use of animal draft power and unstable supply. Human capacity and skills are major constraints in the manufacturing of animal draft inputs.

Two retail stores (BrazAfric and Tasha Enterprises) located in Kigali sell animal drawn implements. These outlet imports the implements from China, Uganda and Kenya. While there are no supply related constraints, the demand for such implements are low in Rwanda. Through various programs and projects in the past, some co-operatives have also accumulated drum seeders (rice), land levelers and rotary weeders.

4.3.3. Tractors and Related Implements

Following the import of new machineries, MINAGRI has set up a workshop facility at Kabuye, Kigali. A mobile workshop has also been set to attend to installation and problems faced by the new buyers and already existing owners of farm machineries. Tractors of other makes such as Massey Fergusson and Ford could also be found in the Eastern province. The retail outlets in the country do not sell spare parts or tractor drawn implements, as the demand is very low, although they could be sourced from Uganda and Kenya. The imports and distribution of farm machinery and farm equipment meet the existing levels of demands of the farming community. The repair and maintenance services however do not support the efficient use of farm machinery and equipment.

4.3.4. Agro-processing

Depending on the stages, processing can be classified into primary- and secondary processing. In primary processing, the valuable part of the harvested produce is not changed, seed for instance. In the secondary processing, the form of the produce is changed, flour and paste for example. While the primary processing activities can be organized near the farm in rural areas, the secondary processing is often done in a larger scale off the farm. The two retail outlets in Kigali supply coffee bean washers, rice threshers, graters, shellers, dehullers, bag stichers, electric motors, and pumps. They are imported from Uganda, Kenya, China and India.

Industrial processing of some crops is well established in Rwanda. Tea (OCIRTHE), Coffee (OCIRCAFE), rice (ICM, Co-operatives), maize (MINIMEX) and wheat are the major crops that are processed on a commercial scale. A group of women in the South province is engaged in commercial processing of soya beans.

4.4. Human Resources

Rwanda has plenty of artisans (blacksmiths, carpenters, tinsmiths and metalworkers). These artisans however lack exposure to farm machineries and implements. Hence there is a great need for enlightening the requirements of field operations and the design of common implements amongst the rural artisans.

The rapid rise in number of cars and vehicles in the recent years have produced a significant amount of personnel who can operate heavy machineries in the country. Nevertheless maneuvering 2 and 4-wheel tractors in the difficult agricultural terrains require additional sets of skills and experience. There is a growing number of mechanics in Rwanda who have basic workshop skills, tools and mechanical acumen with which they can handle repair and maintenance of engines and other mechanical elements of automobiles.

There is an acute shortage of mechanical engineers who can design or modify farm machineries and implements to suit to the local needs. Rwanda Agriculture Development Authority (RADA) employs two officers with background in agricultural mechanization. The shortage of engineers (with diploma or degree in mechanical engineering) in Rwanda makes it difficult to push on mechanization initiatives at the district- and sector levels. Institut des Sciences Agronomiques du Rwanda (ISAR) which runs animal breeding and animal nutrition programs at Rubona is inadequately staffed.

Lack of human resources and inadequate structural integration of extension workers with research and development information sources have lead to weakening of agricultural extension system in Rwanda. Nevertheless, the extension services currently provide some degree of support for adoption of draught animals and farm mechanization.

The emphasis on agricultural mechanization at various levels of educational system is growing in Rwanda. Institute of Agriculture and Animal Husbandry (ISAE) and Nyagatare Agricultural University offer degree programs on agricultural mechanization. Courses on farm machineries are also offered as part of the agriculture/rural development degree programs at Umutara Politecnique, Kibungo University of Agriculture, ULK Gisenyi, UCK and National University of Rwanda.

4.5. Current Policies

The government is attempting to encourage agricultural mechanization in the country, in consistence with long term strategies. In coherence with its regional and global trade regulations, the government does not provide the recently procured machineries and the associated farm implements for free. These machineries are instead sold through a lease agreement wherein the machineries serve as a collateral or security against the capital. To create demand for mechanization, the government covers the overhead costs (import taxes, transportation and initial installation and maintenance services). Through a memorandum of understanding with Banque Rwandaise de Développement (BRD) to lease out power tillers, 4-wheel tractors, rice transplanters. MINAGRI assigns the ownership of these machineries to BRD which leases out to farmers for credit. The lease period can vary between 2 to 5 years at a reduced interest rate of 8.5%. The farmer has to make 20% of the capital as down payment, and pays the rest of the capital along with interest on a monthly and quarterly basis. Upon clearing the capital and the interest to BRD, the farmer can own the machineries. Under this scheme, the government waives importation costs and taxes. To promote mechanization, BRD deposits the money collected from the investments into a separate account, and use it to buy further machineries under the scheme. Rural Investment Facility (RIF) contributes 20% of the investments (final term payment) on machineries under category III.

Subsequent to the overall globalization efforts and entry into East African Community (EAC), the government has aligned its industrial, trade and fiscal policies with that of the region. Today farm machineries and the spare parts from the region can be imported by individuals, programs and projects with relative ease. With its political and economical stability, Rwanda is also considered as an entry point for East African region by multinational companies such as TYM Inc. in setting up the manufacturing and assembling centres.

5. Strategy Formulations

If Rwandan agriculture is to be transformed into a market oriented sector as outlined in Vision 2020 and PSTA II, labor productivity must be increased substantially and agricultural commodity chains should be modernized. Hence the proposed agricultural mechanization strategies aspire to increase the share of motor- and animal power substantially by 2020.

5.1. Vision

It is envisioned that by 2015 about 25% of agricultural field operations will become mechanized in Rwanda. This would imply that one in every 4 Rwandan farmers will either use or hire mechanization services by 2015.

5.2. Objectives

The proposed strategy aspires to apply mechanization as one of the major inputs in agriculture and thereby serve as a catalyst for rural development. More specifically, the mechanization efforts aim to achieve the following objectives:

- raise the power inputs of farming activities, thereby putting more land into production
- decrease drudgery in field operations, thereby enhancing quality of life of rural men and women
- improve the timeliness and efficiency of field work
- carry out tasks that are otherwise difficult to perform without mechanical means
- advance the quality and value of agricultural produce and processed products of Rwanda
- provide entrepreneurship opportunities and sustainable rural livelihoods, and
- facilitate crop processing and thereby improve rural economic opportunities

5.3. Framework

Enabling access to mechanization, skill development and strengthening of commodity chains will serve as the three key drivers in promoting agricultural mechanization in Rwanda.

5.4. Strategic Axes of Intervention

5.4.1. Enabling access to mechanization

Given the diversity in terrain types of Rwanda, the appropriate choice of mechanized inputs in farm operations have a significant effect on agricultural production and productivity, the profitability of farming, and on the environment. Ultimately, the farmer and other end users should make a decision on usage and the levels of mechanization options.

5.4.1.1. Field Mechanization Options for Rwanda

The three major variables which influence mechanization in Rwanda are terrain, crop type and scale of operation. Table 6 summarizes the proposed power options for the identified seven terrains. The scale of operation varies depending on the district with the smallest plots in the north ranging from 0.6 to 3 Ha arable in eastern province.

Table.6. Mechanization options for seven terrains in Rwanda

Terrain	Hand tools	Animal traction	4-wheel tractor	Power Tiller
Flat dry land (Eastern Province)	Use	Use	Use	Limited to weeding and transport.
Terraced slopes (>8 m wide; <16% slope)	Use	Use	Limited Use - Stability problems need to be assessed	Limited to weeding and transport.
Shallow slopes (<16%; South and East)	Use	Use	Stability problems- Suited only for transport and stationery work	Limited to transport and stationery work
Steep slopes (>16%; North and West)	Use	Not applicable	Not Recommended	Not applicable
Steep terraced slopes (>16%; South, North, West)	Use	Use if slope accessible	Not applicable	Not applicable
Wet lands (All provinces)	Use	Use	Use if traction not constrained by moisture	Not applicable
Marshlands	Use	Use for primary tillage	Limited to transport and field operations when the land is dry	Use for land preparation, harvesting and transport
Volcanic soils	Use	Difficult	Not applicable	Not applicable

Animal draft power shall serve as a viable option in gentle slopes and in regions where grazing is not difficult, even though farmers in other African countries such as Tanzania, Uganda and Kenya find that the resource requirements (human and feed) of maintaining animals are relatively higher than that of machines. The requirements of power shall generally vary depending on the nature of operations, type of crop and soil type. The power source options are summarized in Table 7. Details on the selection process for mechanization are given in Annexes 1 to 6.

Table.7. Implements required for field operations.

Operation	Hand tool options	Animal drawn options	Tractor drawn options
Soil loosening depth	Hoe or pick	Mouldboard plough or ripper	Mouldboard or disc plough, ripper or heavy disc harrow
Creating a fine tilth	Hoe	Tooth harrow	Disc harrow or rotavator
Creating ridges	Hoe/shovel	Mouldboard plough,	Mouldboard or disc ridger

		mouldboard ridger or disc ridger	
Crop establishment (planting)	Hoe	Planter or mouldboard plough	Planter, broadcaster
Basal fertiliser application		Planter	Planter or broadcaster
Pest control	Knapsack sprayer		Boom sprayer
Weed control	Hoe, knapsack sprayer	Mouldboard plough, cultivator	Boom sprayer, mechanical weeder
Harvesting	Hoe, knife, machete	Reciprocating cutter, groundnut lifter	Combine harvester, reciprocating cutter bar mower

5.4.1.2. Improving Supply Chains

5.4.1.2.1. Requirements of farm power

To accomplish 25% mechanization in field operations in a total cultivated area of 1,205,090 Ha with an average size of 0.76 Ha per agricultural household, 396,411 farmers will use some levels of mechanical/animal power in their field operations. This would imply that on an average, one in every 4 farmers will own or avail (hire) services of mechanization. Assuming that 10% of the targeted farmers (one in every 40 farmers) will own the machineries themselves and the remainder of targeted farmers will hire the mechanization services. Since animal draft power requires the precious land for grazing and gives relatively lower profitability^{8,9} when compared to motorized power, the share of motorized field operations shall be set higher for mechanization in Rwanda. Accordingly, the share of power tillers, tractors and draft animals are set as 50%, 40% and 10% respectively. The target figures of power tillers, tractors and draft animals (10%) for 39,641 farmers are shown in Table 8. The current level of inventories is shown for 2010. The target shall be achieved at incremental rates of 2%, 5%, 15%, 28% and 50% respectively over the next five years. The incremental figures of power tillers, tractors and draft animals are seen in Table 8.

Table.8. Targets of Farm power sources for 5 years.

	2010	2011	2012	2013	2014	2015
Power Tillers	50	346	991	2973	5550	9910
Tractors	100	217	793	2378	4440	7928
Draft Animals	40	79	198	595	1070	1982

It is important to initially assess the performance and profitability of mechanization options in the different terrains, and make appropriate modifications before farmers and other end-users are advised of the options. It is perceivable that power tillers can serve as an attractive 'entry point' for

⁸ Panin, A . 1994. Empirical evidence of mechanization effects on smallholder crop production systems in Botswana. *Agricultural Systems*, 47: 199–210.

⁹ Sims BG, Kienzle J (2006) *Farm power and mechanization for small farms in sub-Saharan Africa*. FAO, Rome

mechanization in Rwanda. Its relatively cheaper cost (approximately \$1500), efficiency, versatility and manoeuvrability in small farms can find several ownerships in Rwanda. Furthermore, the rising incomes of rice growers in Rwanda and its suitability, power tillers and thereby other means of mechanization shall have an increased rate of adoption amongst farmers. Hence 50% of the mechanization target level shall be achieved by promoting power tillers.

In agricultural mechanization investment opportunities include (i) manufacturing and assembling of machineries and implements, (ii) manufacturing of post harvest processing machines and storage facilities, (iii) importation and distribution of spare parts, and (iv) establishment of private machinery hiring services centers. The government needs to attract local and foreign investments in the above areas in order to sustain mechanization in Rwanda.

5.4.1.2.2. Irrigation as a primer for farm mechanization in small holder farms

Given the importance of climatic change, irrigation is likely to become more important for Rwandan agriculture. Since increasing the irrigated area in Rwanda would make a major contribution to its agricultural productivity, public investments in large irrigation schemes shall become a long-term strategy. Yet much can be achieved in small irrigation schemes for small holder farms and in small groups of farms, where in opportunities for sales of pumps, diesel engines and related equipment shall be created.

By serving as a primer, irrigation shall also create a parallel mechanization opportunity in small holder farms. The versatility of the engines fitted in tractors and power tillers to pump water and deliver through hoses shall make it easier for small holder farmers to avail mechanization in irrigation in small scales. Other operations such as fertigation (fertilizer application through irrigation) can be done more uniformly and efficiently in small and medium size farms if they are applied using motorized pumping of water.

When coupled with irrigation, mechanization schemes have been successful in many countries in Africa¹⁰. For example, the Gezira Scheme in Sudan has a history of mechanization that goes back to 1924 when steam was the motor power before internal combustion engines took over. By the 1970s, 100,000 tenant farmers were cropping 760,000 ha with the assistance of mechanized cultivation services provided by the scheme under contract. In Ghana, the Government has embarked on a program of mechanization to relieve labor shortages in parallel with the expansion of irrigated agriculture from 8,000 ha to 20,000 ha. In the subsequent years (2004-2007), 5,000 tractors were imported and sold to farmers.

5.4.1.3. Financing

Facilitation of access to credit represents an important strategy in enabling agricultural mechanization. The financial sector must be able to provide the necessary capital for the entrepreneurs, the farming community and other end-users. In this context, the economic feasibility and the profitability of the various mechanization options must be made available to the stakeholders (farmers, end users, entrepreneurs, private sector) involved in financing in Rwanda.

¹⁰ Planning investment for enhanced agricultural productivity. Report of an Expert Group Meeting: Agricultural mechanization in Africa - Time for action. FAO (2008)

Special attention should be placed on increasing the profitability of investments in mechanization by encouraging commercial agriculture and focusing investments and support.

Currently BRD is the only bank engaged in leasing farm machineries to farmers and co-operatives. The government shall expand the sources of credit facilities through other banks that have good reach in rural areas. Since the machineries themselves are used as the security against the loans, the government shall motivate and engage other microfinance institutions in providing loans to farmers. The government shall continue to facilitate soft loans with below the market rate of interest for potential farmers. The repayment of loans can be made easy by setting longer repayment periods and adjusting the term payments to the end of each agricultural season, instead of monthly and quarterly options. Minimizing the lower limits of loan amounts (from the current 15 million FRW) and add-on features of loans will promote usage of small implements. Separate term financing products shall also be made available for draught animals and implements. Government should play a role in increasing the distribution of financial products by creating liaisons between financial service providers, farmers and end-users, and encouraging creation of a multitude of term financing products for machineries and equipments in rural areas.

Efforts are also needed to help cooperatives establish strong business models and financial plans. The cooperatives shall use their collective bargaining power to leverage and avail the loan facilities for the machineries. Government shall consider providing credit guarantees to local banks to provide loans to those co-operatives who have a potential for managing agricultural machinery services and repaying the loans, UCORIBU for example. Government shall also encourage partnerships and strategic alliances among co-operatives, NGOs, equipment suppliers and dealers, and financial institutions. Through partnerships and strategic alliances, it is generally easier to negotiate better conditions and to reduce some of the moral hazards and risks in financial services.

To encourage rural women entrepreneurs in the provision of financial and/or mechanization services, the government shall persuade formation of self-help groups, such as that in India¹¹. A self-help group (SHG) is a village-based financial intermediary usually composed of 10-15 local women who voluntarily come together to save regular small sums of money. SHGs either invest the money in ventures such as service provision or lend money to needy farmers in the villages. The group members use collective wisdom and peer pressure to ensure proper end-use of credit and timely repayment. This system eliminates the need for collateral and is closely related to that of solidarity lending, widely used by microfinance institutions.

5.4.1.4. Support Services

Development of service enterprises by entrepreneurial farmers who are ready to invest in machinery and implements for use on their farms as well as for providing mechanization services to the small-scale farmers who are unable to organize such levels of capital investments is paramount to the success of mechanization in Rwanda. Experience from China and India suggests that it is such

¹¹ Fouillet C, Augsburg B (2007) "Spread of the Self-Help Groups Banking Linkage Programme in India", International Conference on Rural Finance Research: Moving Results, held by FAO and IFAD, Rome, March 19-21.

farmers who play a major role in widening the scale of mechanization in small holder farms. Awareness on the scope for generation of additional income through off-farm services such as transport and construction work, cost-benefit ratio, break-even points need to be created amongst potential entrepreneurs. They are also likely to create large enough demand for inputs and produce large volumes of outputs to enable viable and sustainable input supply and output recovery enterprises. A vibrant and competitive service enterprise can also serve the small-scale farmers at viable prices (rates).

There is a strong need to establish efficient and effective distribution channels for equipment, spare parts and repair services, as well as other supplies such as fuel and oil. Initially, the government shall help establish service centers through business ventures with co-operatives or private entrepreneurs in Eastern province. The government shall then gradually withdraw and promote local business in rural areas by encouraging local entrepreneurs in setting up centers for machinery services and spare parts themselves in other parts of the country.

Rwanda Bureau of Standards (RBS) should establish standards and safety regulations for spare parts, implements and machineries, and certify machineries. Field testing and demonstration facilities for agricultural machinery and implements for quality control shall also be established in such centers for the benefit of farmers and manufacturers. The proposed Department for Agricultural Infrastructure and Mechanization (DAIM) and other institutions engaged in agricultural mechanization should recommend and make required amendments to the standards of implements to suit local conditions. RBS in collaboration with these organizations should routinely examine the standards of service operations.

5.4.1.5. Enabling designs

In collaboration with regional and international organizations, institutions such as ISAR, ISAE and universities should engage in research on new designs and/or modifications of available designs that are suited to the local working conditions and the diverse terrains through collaborations with regional/international organizations and institutions.

To reduce drudgery and improve human labor productivity, there is a need to improve the design of existing hand tools. Ergonomic tools and women-friendly tools in farming operations that could significantly enhance human labor productivity in different terrains should be introduced through programs and projects. Draught animal power operations will also require ergonomically designed harnesses, yokes and improved implements such as seed cum fertilizer drills, planters and multi row inter culture implements. Emphasis may be given for introducing multi crop equipment such as medium range multi-crop axial flow threshers, multi-crop reapers and roto-tillers suitable by bringing about design improvement to suit the crops and the terrain.

Designs of marshlands and terraces built on the slopes should allow movement of power tillers and machineries in and around the fields. Providing access to individual fields in marshlands for example, will significantly improve adoption of mechanization. Construction and regular maintenance of metal and non-metal roads in marshlands and rural areas will improve the sustainability of mechanization services availed by small holder farmers in remote areas. Safety

regulations such as roll-over protection features for tractors, operational procedures, and handling of implements should be established, redesigned if necessary and strictly adhered.

Environmentally friendly mechanization practices that conserve natural resources such as land, water and soil nutrients need to be promoted. Mechanization options that allow direct sowing, minimum/reduced tillage, land leveling, retention of crop residues will result in sustainable economic growth. The outstanding success of no-till and conservation agriculture practices in Brazil and India is a good example of the approach to be taken. Projects for bio-fuels from *Jatropha* and other plant products may be created in a few potential rural areas as a model for processing the bio-fuels and making them available to the power tillers, tractors and other processing machines. Taxable income concessions on costs incurred in environmental conservation of farming land shall be introduced.

5.4.2. Skill Development

Increasing the capacity and skill levels of human resources should be a major priority in promoting agricultural mechanization in Rwanda. Skills are needed along the entire supply and value chains – artisans, operators, and farmers, other end-users, service providers (mechanics, engineers), suppliers and extension agents.

5.4.2.1. Technical Skills

Lack of basic technical skills, in driving for example, can severely hinder an otherwise potential farmer towards mechanization. To promote basic skills, government can schedule training opportunities for farmers in different parts of the country by sending authorized trainers at regular intervals during the off-season. The trainers shall teach basic operations and safety issues of power tillers, tractors on a voluntary basis. Car driving schools in each sector shall be authorized to coach and license driving of tractors and power tillers.

Training and upgrading sessions for artisans and automobile mechanics shall also be conducted in each sector. Special certificate courses (1 to 6 months) that will develop skills and offer hands-on training on the design, use and maintenance of machineries and implements, and on management of workshops need to be developed for technicians and service providers. Farmers and service providers should also receive training on how to make the integrated use of farm machinery with other inputs more efficient. Such courses shall be offered and sponsored at educational institutions such as ISAE by MINAGRI.

To develop an active agricultural engineering sector in the country, specialized departments shall be set up in major agricultural institutions of Rwanda to support and gear farm mechanization in particular through education, research and development. Key institutions such as ISAR, ISAE and RADA should closely work with artisans, farmers and service providers in modifying and developing appropriate tools and machines for local farm use based on their interaction with farmers and their assessment of the potential of the mechanization scenario. In addition to mechanization, agriculture educational institutions should also include animal health and animal nutrition as mainstream subjects in all colleges and universities offering agriculture degree programs. Technical capacities on breeding, health, and nutrition of animals should be enhanced at national research

and development institutions such as ISAR and RADA. In the interim, government shall encourage graduate and/or post graduate students to undertake formal studies in agricultural engineering from reputed institutions abroad to build human capacities in the field of farm mechanization.

A Rwanda Agricultural Mechanization Board may be set up at national level with Agriculture Minister as its Chairman. The Mechanization Board shall serve as a nodal agency for implementation of mechanization strategies and policies by establishing linkages with manufacturing, financial, human resources, technology and extension institutions, and shall constantly monitor the progress of mechanization in the country. Through interactions with other ministries, manufacturers, research and extension agencies, the board may elicit feedbacks for correction in problems as well as for future research and development based on farmers' need.

5.4.2.2. Knowledge creation

Given the low level of mechanization in the country, there is an enormous need for adoption program in the country. The extension programs on mechanization should include front line demonstration, agricultural machinery shows, media, publications and face-to-face contacts with farmers and co-operatives. The government can absorb and place the new flow of diploma graduates specialized in agricultural mechanization produced as extension agents across the country. NGOs and other international aid programs and projects can also play an important role in educating farmers on the feasibility and sustainability of farm mechanization. The extension services should place more emphasis on the development of small-scale farmers in:

- the use of appropriate and affordable mechanization options
- credit acquisition
- effective supply of agricultural inputs (including spares)
- encouraging farmers' co-operatives to participate in availing and providing services of agricultural machineries and
- basic knowledge on animal health and nutrition

The proposed DAIM should undertake a massive extension program on farm machineries. DAIM should effectively use the graduates specializing in agricultural mechanization from ISAE for instance. The government should also provide in-service training for existing staff, technicians and artisans to improve their understanding of the different power and mechanization options available to farmers and to expose them to new technologies and opportunities.

Local manufacture of agricultural machineries and implements can be promoted through trainings on village-level craftsmanship, manufacturing technology, operation, repair, and maintenance. The proposed steel industry near Rwamagana shall improve the availability of steel (bars and plates) in local markets. Local manufacturers can be provided with technical assistance on the fabrication of prototypes of machines and spare parts.

5.4.3. Agro-processing

Agricultural mechanization in harvesting, post-harvest handling and storage processes shall initiate the path towards commercialization of agriculture. Farmers in Rwanda need to realize the

importance of quality of agricultural produce on the value chain. Besides raising the competitiveness of their produces, it will also raise their profitability and sustainability.

5.4.3.1. Establishing Linkages

Smallholder farmers need to be sensitized on the importance of linkages with processors and market. This shall be done by creating awareness programs emphasizing the importance of post harvest technologies on efficient processing and its effect on prices. Appropriate use of mechanization options in post-harvest handling such as mechanical threshers, winnowing machines, shellers, de-hullers, driers (using heat from electrical power or crop residues such as rice husks) and motorized transportation that can, not only reduce the post-harvest losses but also, improve the quality of agricultural produces should be actively promoted.

While secondary processing shall be concentrated on medium to large scale industries, small to medium scale primary processing of maize, sunflower, sorghum, soybean, groundnut, beans and potato shall be explored in locations closer to the production in rural areas. Women entrepreneurs capable of setting up small-scale industries on processing and value addition in rural areas (at locations close to the source of production) need to be encouraged. In addition, mechanization that can improve the management of crop by residues such as straws, cobs, shells through composting or processing should also be promoted. The sustainability of agro-processing shall be ensured by routine examination of standards of machines and operations by RBS.

Given the regional dynamics in trading regulations under East African Community (EAC), smallholder farmers in Rwanda need to be informed of the importance of competitiveness and newer avenues to access markets. Through various programs and projects, the government shall provide the necessary market information and construct the missing linkages in commodity chains along the production – processing – marketing continuum by offering appropriate mechanization options on post harvest handling, storage and processing of agricultural produces.

5.4.3.2. Building Entrepreneurship

Mechanization of activities in commodity chain enables creation of small to medium scale agro-processing industries in rural areas that can provide employment in handling, packaging, processing, transporting, and marketing of agricultural commodities. Small scale processing requires relatively little capital investment and housing. Government needs to establish environments that are conducive to establishment and operation of agro-processing industries.

NGOs and non-government projects and programs revolving around the theme of commodity chains such as Post Harvest Handling and Storage (PHHS; USAID, Rwanda) need to also promote appropriate agro processing technologies in specific areas where the crop produces of interest are intensively produced. By engaging such stakeholders, the government need to sensitize and build entrepreneurships through training and workshops on small- and medium scale agro-processing industries. The government shall also build capacity of private agro processing support service providers by providing training to existing processors. For instance, farmers require training on threshing/de-hulling of cereal grains, processing of sugar cane (jaggery) and cattle feed mills.

One way to promote agro-processing among small holder farmers and small investors in villages is to help them organize into groups or associations. These organizations can establish more efficient scales of operation and utilization for many types of machinery through resource-sharing mechanisms. In this context, members of co-operatives have a better chance to branch out and become agricultural equipment service providers to their own group members. In this way, business and entrepreneurship can evolve from the bottom up and may spread to medium-scale and larger scale sustainable scenarios.

Increased capitalization of agro-processing needs sources of finance from the private sector. The financial sector and government should work with commercially oriented farmers and entrepreneurs in order to strike the necessary financial deals that are required for agro-processing industries. The government shall promote private investments in primary processing by coming out with a clear incentive package. The government shall also consider 100% first year capital allowance for plant and machinery used in primary and secondary agro-processing. The agricultural machineries and implements in processing shall be exempted from import duty and value added tax (VAT). Subsidization of machineries/implements for small- and medium holder farmers in the short-term shall also be envisioned where the costs of machineries can be subsidized during the initial period (2 to 3 years) after introduction and thereafter withdrawn gradually to zero subsidies on investments.

To create demand for mechanization in agro-processing, it is important that the energy demands are met by increasing the availability of fuel and electrical power in the rural areas. By creating higher grid power connectivity for uninterrupted power supply, the villages should be provided with increased electric power.

6. Roles and Responsibilities of Stakeholders

Government needs to continue to make the first moves, such as importing the first consignment of machineries and implements. After the initial wave of investment, the government shall import in partnership with the private enterprise, and thereafter allowing the private sector to take over. Government shall gradually move towards a comprehensive privatization policy that will help reduce costs and prices and widen farmers' choice. The State shall however act as a catalyst ensuring that mechanization, human resources and legal frameworks are geared towards stimulating farm productivity and private investment.

The government (public-sector), private-sector agencies and the end-users need to play several important roles in implementation of mechanization strategies. The ideal situation involves "Triple Helix Model" in which government, public institutions and industry are entwined in a mutually supportive cooperative endeavor. Broad partnerships are required between government tasks that will cut across infrastructure, education, health, gender, transport, natural resources (including water), fiscal measures and legislation.

Government has a role in the broad field of education and training in the creation, funding and management of institutions responsible for the acquisition of knowledge (adaptive research for the

hills and the associated slopes), and in its dissemination. Development of the required skills and extension services to farmers and other end-users need to be provided by the government. Government may have a role in facilitating trade relationships with new suppliers of technology or equipment. Support with supply and demand contacts, management and finance securities or tax waivers would help the private sector to come up to gain momentum in a relatively short period.

RBS and institutions such as ISAR, ISAE, RADA and the proposed DAIM shall be responsible for ensuring the quality and quantity of mechanization in the country. The national DAIM office could play a facilitative role in identifying potential product suppliers and inviting them to attend the field days organised for farmers. The sector agronomist should work closely with local level service providers and product retailers.

The private sector shall look after the provision of farm inputs including farm machinery and the associated machinery support services (supply, repair and maintenance of equipments). Building close relationships with the farmers, assessing needs and satisfying demands, while competing with peer companies, are all part of the business venture. In such operational scenarios, the demand for mechanization is likely to be satisfied and the agricultural productivity enhanced. Operations are best conducted under commercial enterprises requiring adequate investment and offering the opportunity to make profitable commercial returns. Local manufacturing can be logically preceded by profitable importation, assembly and distribution support businesses in Rwanda.

7. Co-ordination, Monitoring and Evaluation

The outputs and the effects on the intended beneficiaries outlined here will be monitored by MINAGRI. The institutions and programs who are assigned with responsibilities of the various activities listed under logical framework of agricultural mechanization strategies will need to elaborate and establish further details of methodology and work plan. Each component will be implemented through annual work plans (activities, time frame, and budget) that are formulated in terms of the milestones to be accomplished. The proposed Agricultural mechanization board and/or the Program 1 under PSTA-II shall review all work plans and budgets and will monitor progress internally and annually.

Progress on the activities in general, will be regularly evaluated by comparing the outputs and milestones against the proposed key indicators. Information on the progress according to the program's plans and schedules will be gathered. The review will provide decision-makers with detailed assessment of the achievements, failures, weaknesses, constraints, opportunities, challenges, lessons learnt, cases and the way forward arising from implementation of the proposed strategies at organizational and field levels, as they pertain to beneficiaries. Based on the record of outputs, effects and impacts, the strategy activities and work plan shall further be modified to attain the set goals.

7.1. Action plan and Time Table

Strategy	Specific Objective	Activities	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
1. Enabling access to Mechanization	1.1. Establish mechanization options for the different terrains	1.1.1. Assess the performance and economic feasibility of the proposed mechanization options						
		1.1.2. Amend and recommend appropriate modifications of the options, if any						
		1.1.3. Promote and make mechanization options available to farmers, service providers and other end-users						
	1.2. Develop supply chains governing farm power and implements, and create demand	1.2.1. Perform market studies on the demand for machineries and implements						
		1.2.2. Identify potential enterprises that can supply inputs in Rwanda						
		1.2.3. Attract local and foreign investments in manufacturing and/or assembling of spare parts and machineries in Rwanda						
		1.2.4. Facilitate the availability of farm machineries and implements						
		1.2.5. Ascertain the feasibility of small diesel engines and pumps in irrigation in different terrains						
		1.2.6. Establish the usability of engines of power tillers and tractors in fertigation						
	1.3. Facilitate improved access to credit of farmers, end-users and service providers on machineries and implements	1.3.1. Determine the economic feasibility of mechanization options for different terrains						
		1.3.2. Engage rural banks and microfinance institutions in providing credit to end-users						
		1.3.3. Generate a multitude of term financing products in availing farm machineries and implements						
		1.3.4. Help establish business plans, strategies and projects for potential co-operatives						
		1.3.5. Identify and provide credit guarantees to promising co-operatives						
		1.3.6. Encourage rural entrepreneurs and women groups in providing financial and/or mechanization services						
	1.4. Develop mechanization service enterprises	1.4.1. Craft standards of machineries, implements, spare parts and service operations						
		1.4.2. Establish effective and efficient distribution channels for spare parts and repair services						
	1.5. Ascertain the appropriateness of existing	1.5.1. Identify ergonomic tools that would reduced drudgery of human labor and improve the efficiency of draught animals						

Strategy	Specific Objective	Activities	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
	designs of proposed farm machineries and implements	1.5.2. Propose structural adjustments in marshlands and terraces to enable access of farm machineries to interiors						
		1.5.3. Select and promote mechanization practices that conserve natural resources (land, water and fuel energy)						
2. Develop broad-based skills and strengthen capacity in agricultural mechanization	2.1. Build basic skills of rural artisans, operators, mechanics and service providers, and technical capacity of personnel engaged in research and development	2.1.1. Conduct on-farm training on basic operations and maneuvering of tractor- and power tiller operators						
		2.1.2. Upgrade rural artisans, mechanics and service providers on the design of farm machineries and implements						
		2.1.3. Offer short term certificate courses on design, use and maintenance of machineries and implements						
		2.1.4. Raise human capacity in the field of agricultural mechanization						
	2.2. Raise knowledge and awareness on farm machineries and implements through extension services	2.2.1. Recruit and provide in-service training to extension agents						
		2.2.2. Prepare multi-media publications and conduct demonstrations and agricultural machinery shows						
		2.2.3. Create awareness on revenue generation from off-farm and service provision to potential entrepreneurs						
	3. Promote mechanization in agro-processing to improve rural livelihoods	3.1. Establish linkages along the continuum of production-processing-marketing	3.1.1. Conduct sensitization stakeholders workshop to nurture opportunities in small and medium processing					
3.1.2. Build capacity of primary agro processing and service providers								
3.2. Facilitate private sector investment in small and medium scale processing of agricultural commodities		3.2.1. Enhance access to improved post harvest and processing technologies through training and workshops						
		3.2.2. Facilitate establishment of groups, associations and forums of processors						
		3.2.3. Increase financing for small and medium scale agro-processing enterprises in rural areas						

7.2. Cost Estimate

Strategy	Activities	2010-11	2011-12	2012-13	2013-14	2014-15	Total (RWF)	Total (USD)
1. Enabling access to Mechanization	1.1.1. Assess the performance and socio-economic feasibility of the proposed mechanization options	1,000,000					1,000,000	1,754
	1.1.2. Amend and recommend appropriate modifications of the options, if any	250,000					250,000	439
	1.1.3. Promote and make mechanization options available to farmers, service providers and other end-users*	837,156,438	2,768,671,094	8,304,553,281	730,000	730,000	11,911,840,813	20,897,966
	1.2.1. Perform market studies on the demand for machineries and implements		250,000				250,000	439
	1.2.2. Identify potential enterprises that can supply inputs in Rwanda	250,000	250,000				500,000	877
	1.2.3. Attract local and foreign investments in manufacturing and/or assembling of spare parts and machineries in Rwanda	400,000	400,000				800,000	1,404
	1.2.4. Facilitate the availability of farm machineries and implements	521,429	521,429	521,429	521,429	521,429	2,607,143	4,574
	1.2.5. Ascertain the feasibility of small diesel engines and pumps in irrigation in different terrains	400,000	400,000				800,000	1,404
	1.2.6. Establish the usability of engines of power tillers and tractors in fertigation	400,000	400,000				800,000	1,404
	1.3.1. Determine the profitability of mechanization options for different terrains		400,000	400,000			800,000	1,404
	1.3.2. Engage rural banks and microfinance institutions in providing credit to end-users	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
	1.3.3. Generate a multitude of term financing products in availing farm machineries and implements	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193

Strategy	Activities	2010-11	2011-12	2012-13	2013-14	2014-15	Total (RWF)	Total (USD)
	1.3.4. Help establish business plans, strategies and projects for potential co-operatives	3,000,000	3,000,000				6,000,000	10,526
	1.3.5. Identify and provide credit guarantees to promising co-operatives		400,000				400,000	702
	1.3.6. Encourage rural entrepreneurs and women groups in providing financial and/or mechanization services	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
	1.4.1. Craft standards of machineries, implements, spare parts and service operations	250,000	250,000				500,000	877
	1.4.2. Establish effective and efficient distribution channels for spare parts and repair services	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
	1.5.1. Identify ergonomic tools that would reduced drudgery of human labor and improve the efficiency of draught animals		250,000	250,000	250,000	250,000	1,000,000	1,754
	1.5.2. Propose structural adjustments in marshlands and terraces to enable access of farm machineries to interiors	250,000	250,000				500,000	877
	1.5.3. Select and promote mechanization practices that conserve natural resources (land, water and fuel energy)	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
2. Develop broad-based skills and strengthen capacity in agricultural mechanization	2.1.1. Conduct on-farm training on basic operations and maneuvering of tractor- and power tiller operators	750,000	750,000	750,000	750,000	750,000	3,750,000	6,579
	2.1.2. Upgrade rural artisans, mechanics and service providers on the design of farm machineries and implements	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
	2.1.3. Offer short term certificate courses on design, use and maintenance of machineries and implements	750,000	750,000	750,000	750,000		3,000,000	5,263
	2.1.4. Raise human capacity in the field of agricultural mechanization	12,000,000	12,000,000	12,000,000			36,000,000	63,158

Strategy	Activities	2010-11	2011-12	2012-13	2013-14	2014-15	Total (RWF)	Total (USD)
	2.2.1. Recruit and provide in-service training to extension agents		12,000,000	12,000,000	12,000,000	12,000,000	48,000,000	84,211
	2.2.2. Prepare multi-media publications and conduct demonstrations and agricultural machinery shows	730,000	730,000	730,000	730,000	730,000	3,650,000	6,404
	2.2.3. Create awareness on revenue generation from off-farm and service provision to potential entrepreneurs	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
3. Promote mechanization in agro-processing to improve rural livelihoods	3.1.1. Conduct sensitization stakeholders workshop to nurture opportunities in small and medium processing	750,000	750,000	750,000	750,000		3,000,000	5,263
	3.1.2. Build capacity of primary agro processing and service providers	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
	3.2.1. Enhance access to improved post harvest and processing technologies through training and workshops		250,000	250,000			500,000	877
	3.2.2. Facilitate establishment of groups, associations and forums of processors	250,000	250,000	250,000	250,000	250,000	1,250,000	2,193
	3.2.3. Increase financing for small and medium scale agro-processing enterprises in rural areas	250,000	250,000	250,000	250,000		1,000,000	1,754
	Total (RWF)	861,357,866	2,805,172,522	8,335,454,710	18,981,429	17,231,429	12,038,197,955	21,119,646
	Total (USD; @570 RWF/USD)	1,511,154	4,921,355	14,623,605	33,301	30,231	21,119,646	

* Investments on introducing farm power supplies (shown in Table 8) for the first three financial years included. It is envisioned that following this initial wave of investments, the supply chain will be led by private sector (local and foreign investors).

8. Logical Framework of Agricultural Mechanization Strategies

Strategy	Specific Objective	Activities	Expected Outputs	Indicators	Responsibility	
1. Enabling access to Mechanization	1.1. Establish mechanization options for the different terrains	1.1.1. Assess the performance and socio-economic feasibility of the proposed mechanization options	1.1.1.1. Authenticity of proposed mechanization options for different terrains established	1.1.1.1.1. Reports on assessment and profitability 1.1.1.1.2. Levels of awareness of mechanization options amongst farmers and extension agents	RADA, ISAE, DIAM, PSTAI	
		1.1.2. Amend and recommend appropriate modifications of the options, if any	1.1.2.1. Guidelines on the use of mechanization options for the seven terrains made available	1.1.2.1. Report on design and requirements of machineries and implements		ISAR, ISAE, RADA, PSTAI
		1.1.3. Promote and make mechanization options available to farmers, service providers and other end-users	1.1.3.1. Farm machineries and the suitable implements for various agro climatic conditions become available	1.1.3.1.1. Number of power tillers, tractors and draught animals distributed to farmers		Private sector, MINAGRI
	1.2. Develop supply chains governing farm power and implements, and create demand	1.2.1. Perform market studies on the demand for machineries and implements	1.2.1.1. Demand of farm machineries and implements known to government and private sector	1.2.1.1.1. Inventories and Forecasts of suppliers and government	MINAGRI, Distributors, Dealers, PSTAI	
		1.2.2. Identify potential enterprises that can supply inputs in Rwanda	1.2.2.1. Regional and global enterprises that can supply inputs listed	1.2.2.1.1. Reports and newsletters	MINAGRI	
		1.2.3. Attract local and foreign investments in manufacturing and/or assembling of spare parts and machineries	1.2.3.1. Local manufacturing and/or assembling of spare parts, machineries established	1.2.3.1.1. Number of local and foreign investments in farm mechanization	MINICOM, MINAGRI	
		1.2.4. Facilitate the availability of farm machineries and implements	1.2.4.1. Power tillers, tractors, draught animals and implements distributed	1.2.4.1.1. Number of farmers owning power tillers and draught animals	PSTAI, RADA, DIAM, Extension agents	
		1.2.5. Ascertain the feasibility of small diesel engines and pumps in irrigation in different terrains	1.2.5.1. Irrigation in smallholder farms are mechanized	1.2.5.1.1. Number of diesel engines, pumps in smallholder farmers	Extension agents, RADA, CIP, DIAM, Private entrepreneurs	

Strategy	Specific Objective	Activities	Expected Outputs	Indicators	Responsibility
		1.2.6. Establish the usability of engines of power tillers and tractors in fertigation	1.2.5.2. Irrigation is served as a catalyst for mechanization	1.2.5.2.1. Number of engines of power tillers and tractors used for irrigation and water distribution	Extension agents, RADA, CIP, DIAM
	1.3. Facilitate improved access to credit of farmers, end-users and service providers on machineries and implements	1.3.1. Determine the profitability of mechanization options for different terrains	1.3.1.1. Profitability of owning and provision of farm machineries become available to banks and stakeholders	1.3.1.1.1. Guidelines on profitable mechanization	ISAR, ISAE, RADA, DIAM, PSTAI
		1.3.2. Engage rural banks and microfinance institutions in providing credit to end-users	1.3.2.1. Lending credit for the purchase of farm machineries and implements are available from multiple sources	1.3.2.1.1. Number of loans issued to smallholder farmers	Banks, microfinance and lending institutions,
		1.3.3. Generate a multitude of term financing products in availing farm machineries and implements	1.3.3.1. Diverse options for availing credit, term payments and interest rates available for small holder farmers	1.3.3.1.1. Number of financial products available for owning farm machineries	Financial institutions, MINAGRI
		1.3.4. Help establish business plans, strategies and projects for potential co-operatives	1.3.4.1. Financial strengths of co-operatives leveraged for availing loans	1.3.4.1.1. Units of co-operatives publishing 'balance sheets'	RADA, MINAGRI, Extension agents, PSTAI
		1.3.5. Identify and provide credit guarantees to promising co-operatives	1.3.5.1. Collective access to credit for farm mechanization and service provision available for farmers' co-operatives	1.3.5.1.1. Number of co-operatives availing loans on farm machineries	MINAGRI, Financial institutions
		1.3.6. Encourage rural entrepreneurs and women groups in providing financial and/or mechanization services	1.3.6.1. Increased solidarity lending and service provision in rural areas available for small holder farmers	1.3.6.1.1. Number of leases, women lenders and women service providers in rural areas	RADA, Extension agents
		1.4. Develop mechanization service enterprises	1.4.1. Craft standards of machineries, implements, spare parts and service operations	1.4.1.1. Improvement in quality of machines, accessories and service provision	1.4.1.1.1. Published Standards of machineries and implements

Strategy	Specific Objective	Activities	Expected Outputs	Indicators	Responsibility
		1.4.2. Establish effective and efficient distribution channels for spare parts and repair services	1.4.2.1. Increased availability of spare parts and hiring services for small holder farmers	1.4.2.1.1. Number of retailers, dealers and distributors of spare parts 1.4.2.1.2. Number of farmers providing mechanization services	Dealers, Retailers, Private entrepreneurs, Extension agents, RADA
	1.5. Ascertain the appropriateness of existing designs of proposed farm machineries and implements	1.5.1. Identify ergonomic tools that would reduced drudgery of human labor and improve the efficiency of draught animals	1.5.1.1. Reduced drudgery of human labor	1.5.1.1.1. Number of ergonomic designs created	ISAR, ISAE, DIAM, RADA
1.5.1.2. Increased productivity of human labor and draught animals			1.5.1.2.1. Adoption rates of the ergonomic designs	RADA, Extension agents	
1.5.2. Propose structural adjustments in marshlands and terraces to enable access of farm machineries to interiors		1.5.2.1. Equitable access to farm mechanization for members of farming community in marshlands and terraces	1.5.2.1.1. Number of individual fields/land holdings availing farm mechanization in marshlands and terraces	ISAR, ISAE, DIAM, RADA, RSSP, Extension agents	
1.5.3. Select and promote mechanization practices that conserve natural resources (land, water and fuel energy)		1.5.3.1. Natural resources are protected from any misuse	1.5.3.1.1. Adoption rates of direct seeding, minimum/reduced tillage	ISAR, ISAE, DIAM, RADA, RSSP, Extension agents	
		1.5.3.2. Sustainability of mechanization ensured	1.5.3.2.1. Cost of production, soil fertility and water use efficiency	ISAR, ISAE, DIAM, RADA, RSSP, Extension agents	
2. Develop broad-based skills and strengthen capacity in agricultural mechanization	2.1. Build basic skills of rural artisans, operators, mechanics and service providers, and technical capacity of personnel engaged in research and development	2.1.1. Conduct on-farm training on basic operations and maneuvering of tractor- and power tiller operators	2.1.1. Basic operating skills not limiting the adoption of farm machineries	2.1.1.1. Number of farmers and operators who can drive and operate tractors and power tillers	Driving schools, PSTAIL, RADA
		2.1.2. Upgrade rural artisans, mechanics and service providers on the design of farm machineries and implements	2.1.2.1. Repair and maintenance services for farm equipments, machineries available in rural areas	2.1.2.1.1. Number of artisans, mechanics available in rural areas	ISAE, DIAM, RADA

Strategy	Specific Objective	Activities	Expected Outputs	Indicators	Responsibility
			2.1.2.2. Time and cost of repair and maintenance significantly reduced	2.1.2.2.1. Number of non-working or unused machineries	
		2.1.3. Offer short term certificate courses on design, use and maintenance of machineries and implements	2.1.3.1. Self reliance on fine-tuning and fixing adjustments required for increased local adoption of mechanization	2.1.3.1.1. Number of mechanics, service providers trained	ISAE, DIAM, RADA
		2.1.4. Raise human capacity in the field of agricultural mechanization	2.1.4.1. Graduates and post graduates on farm mechanization and farm animals produced	2.1.4.1.1. Number of degree holders	ISAR, PSTAIL, RADA, DIAM
	2.2. Raise knowledge and awareness on farm machineries and implements through extension services	2.2.1. Recruit and provide in-service training to extension agents	2.2.1.1. Extension agents specialized on agricultural mechanization available across the country	2.2.1.1.1. Number of extension agents recruited	MINAGRI
		2.2.2. Prepare multi-media publications and conduct demonstrations and agricultural machinery shows	2.2.2.1. Knowledge on options, benefits and access of agricultural mechanization enriched amongst farmers	2.2.2.1.1. Number of leaflets, brochures, media shows (radio, TV)	RADA, DIAM, Extension agents
		2.2.3. Create awareness on revenue generation from off-farm and service provision to potential entrepreneurs	2.2.3.1. Sensitization of the profitability of revenues from off-farm activities	2.2.3.1.1. Number of farmers, entrepreneurs, service providers trained	RADA, DIAM, ISAE, Extension agents
3. Promote mechanization in agro-processing to improve rural livelihoods	3.1. Establish linkages along the continuum of production-processing-marketing	3.1.1. Conduct sensitization stakeholders workshop to nurture opportunities in small and medium processing	3.1.1.1. The importance of post harvest handling and storage on quality of agricultural commodities felt by producers	3.1.1.1.1. Number of producers and entrepreneurs trained	RADA, PSTAIL
			3.1.1.2. The spectrum of entrepreneurial possibilities in primary and secondary agro-processing made available	3.1.1.2.1. Catalog of potential agro-enterprises on processing	PSTAIL

Strategy	Specific Objective	Activities	Expected Outputs	Indicators	Responsibility
		3.1.2. Build capacity of primary agro processing and service providers	3.1.2.1. Primary processing of food crops done close to the location of production	3.1.2.1.1. Number of primary processing units set up in production areas 3.1.2.1.2. Number of rural men and women employed in agro-processing enterprises	PSTA II, MINICOM, MINAGRI
			3.1.2.2. Quality of secondary processing outputs improved	3.1.2.2.1. Competitiveness of locally processed commodities	MINICOM, PSTAII
	3.2. Facilitate private sector investment in small and medium scale processing of agricultural commodities	3.2.1. Enhance access to improved post harvest and processing technologies through training and workshops	3.2.1.1. Dissemination of appropriate post harvest technologies and agro-processing opportunities	3.2.1.1.1. Number of new technologies and enterprises created	RADA, PSTAII, Extension agents
		3.2.2. Facilitate establishment of groups, associations and forums of processors	3.2.2.1. Increased access to improved post harvest and processing technologies	3.2.2.1.1. Number of women groups, associations, co-operatives engaged in processing	PSTAII, RADA
		3.2.3. Increase financing for small and medium scale agro-processing enterprises in rural areas	3.2.3.1. Incentive packages for small and medium scale agro-processors	3.2.3.1.1. Gazettes on term finance products for private enterprises involved in agro-processing	MINAGRI, MINICOM
			3.2.3.2. Increased credit access for entrepreneurs engaged in primary and secondary processing	3.2.3.2.1. Number of entrepreneurs availing loans and leases	Banks, Microfinance institutions

Annexes

Annex 1. Proposed Agricultural Mechanisation Systems for Sloped and Terraced Lands¹²

Land specifications

Land slope >12% and <55%

Field dimensions: plot widths 6-8m

Plot lengths limited to 50m for management purposes

Plot shape: curved rectangular

Provinces with these land forms:-Northern, Western and Southern Provinces

Cash crops: - Soya beans, cassava, maize, beans, Irish potato, wheat

Plantation crops: - Coffee, tea and banana

Current mechanisation options for maize, Soya beans, Irish potato.

Primary tillage: - pick, mattock, hoe

Seed bed preparation: - hoe, harrow, shovel

Seed establishment: - hoe

Crop maintenance: - hoe, knapsack sprayer (for herbicides) crop harvesting: - machete, hoe

Crop transport: - Head, wheel barrow

Current mechanising options for plantation crops (banana, tea and coffee)

Soil loosening across field: - pick, mattock, hoe

Second soil loosening (after three weeks):- hoe

Hole digging (600mm diameter and 600mm depth) at a 3*3m spacing-pick, mattock, and hoe

Soil/manure mixing to a depth of 300mm

Placement of tuber-manual labour

Covering of tuber with 50mm of soil- hoe/shovel

Mulching – use of machete to cut loose banana stalks

Pesticide application- knapsack sprayer

Harvesting-machete

New mechanisation options

Justification: The maximum width and lengths of terraces are 8 and 50m respectively. The terrace width of for terraces is too restrictive for the use of conventional tractors. Movement of the tractors between terraces would also pose a major obstacle.

Single axle tractors (walking tractors) do not have the mass or power to pull ploughs on dry soil at the recommended minimum depth of 200mm. They may be used to weed (with a rotavator) and plant (with a row planter) but in both operations they do not offer speed advantages over animal draft.

¹² Strategic Plan for Agricultural Mechanisation Improvement Programme for Rwanda (2009) MINAGRI

Animal draft can be used to mechanise all production operations, on terraces, for maize, sorghum, sunflower, groundnuts with minimum adaptations for specific crop requirements. In addition animal based systems offer significant time and cost based advantages over human powered systems which on their own are regarded as slow, tiresome and limiting to the area cropped by farmers. As a result, only animal draft based mechanisation systems are recommended for upgrading the mechanisation of terraced lands.

The use of animal traction would be facilitated by adoption of longer fields (100m???) and at least 4m at the end of the field (on both sides) to facilitate turning of the animals.

Proposed mechanisation options for the individual production related operations.

(AD – animal drawn)

Primary tillage: - AD reversible mouldboard plough OR ripper tine for minimum tillage operations in which soil inversion is not required.

Seed bed preparation:- AD tooth harrow for crops planted on the flat (maize, sorghum, sunflower, groundnuts) OR a combination of AD harrow and AD ridger for root crops (Irish and sweet potatoes)

Seed establishment:-For crops planted on the flat (maize, sorghum, sunflower, and groundnuts) - AD planter OR AD plough at shallow depth, dropping seed by hand and covering with AD harrow.

For root crops a combination of a hoe and hand planting.

Crop maintenance:-

Weed control

For maize, sorghum, sunflower, groundnuts use of an AD cultivator inter row and manual weeding with a hoe in row OR application of herbicides with a knapsack sprayer. OR manual weeding with a hoe.

For Irish and sweet potato use of a ridger to weed sides of ridges and hand hoe along top or ridge or herbicide application with a knapsack sprayer

Fertiliser application

Basal dressing for Maize, sorghum, sunflower and groundnuts is applied by planter or manually into the planting furrow after furrow opening with a plough.

Top dressing is done manually for all crops.

Crop harvesting:-

Maize –Use of a machete or hoe to cut stem and then piling up of the plants in the field in the form of a stook to dry further in field.

Sorghum – Use of knives to cut head manually

Sunflower- Use of knives to cut sunflower head manually

Groundnuts- Use of AD groundnut lifter (an attachment which can be fitted to a plough beam in place of the plough mouldboard)

Or use of hoes.

Crop transport: - Animal drawn cart on shallow slopes. Head, wheel barrow

Annex 2. Proposed Agricultural Mechanisation Systems for Shallow Sloped Land ¹²

Slopes <20%

Plot sizes are limited.

Plot shapes are irregular

Locations with these land forms are Southern and Eastern Provinces. Isolated places can be found in the other two provinces.

Crops

Maize, sunflower, cassava, beans, sweet potato

Current mechanisation options for maize, soya beans, groundnuts, sunflower, Irish potato, sweet potato:

Primary tillage: - pick, mattock, hoe

Seed bed preparation: - hoe, harrow, shovel

Seed establishment: - hoe

Crop maintenance: - hoe, knapsack sprayer (for herbicides)

Crop harvesting: - machete, hoe

Crop transport: - Head, wheel barrow

New mechanisation options

(AD- animal drawn)

Proposed mechanisation options for the individual production related operations.

Primary tillage: - AD reversible mouldboard plough OR ripper tine for minimum tillage operations in which soil inversion is not required.

Seed bed preparation: - AD tooth harrow for crops planted on the flat (maize, sorghum, sunflower, groundnuts) OR a combination of AD harrow and AD ridger for root crops (Irish and sweet potatoes)

Seed establishment:-For crops planted on the flat (maize, sorghum, sunflower, and groundnuts) - AD planter OR AD ploughs at shallow depth, dropping seed by hand and covering with AD harrow. For root crops a combination of a hoe and hand planting.

Crop maintenance:-

Weed control

For maize, sorghum, sunflower, groundnuts; use of an AD cultivator inter row and manual weeding with a hoe in row (OR) Application of herbicides with a knapsack sprayer (OR) manual weeding with a hoe.

For Irish and sweet potato; use a ridger to weed sides of ridges and hand hoe along top or ridge (OR) perform herbicide application with a knapsack sprayer.

Fertiliser application

Basal dressing for Maize, sorghum, sunflower and groundnuts is applied by planter or manually into the planting furrow after furrow opening with a plough.

Top dressing is done manually for all crops.

Crop harvesting:-

Maize –Use of a machete or hoe to cut stem and then piling up of the plants in the field in the form of a stook to dry further in field.

Sorghum – Use of knives to cut head manually

Sunflower – Use of knives to cut sunflower head manual

Groundnuts – Use of AD groundnut lifter (an attachment which can be fitted to a plough beam in place of the plough mouldboard) or use of hoes.

Crop transport: - Animal drawn cart. Head, wheel barrow

Annex 3. Proposed Agricultural Mechanisation Systems for Flat Dry Land ¹²

Land slope < 5%

Field dimensions: plot widths in excess of 50m
Plot lengths unlimited-commercial type fields)
Plot shape : rectangular

Provinces with these land forms: - East Province and isolated areas in Southern Province.

Crops

Maize, sorghum, sunflower, beans, sweet potato

Current mechanisation options

Current mechanisation options for maize, sorghum, Soya beans, sunflower, and sweet potato.

Primary tillage: - pick, mattock, hoe

Seed bed preparation: - hoe, harrow, shovel

Seed establishment: - hoe

Crop maintenance: - hoe, knapsack sprayer (for herbicides)

Crop harvesting: - machete, hoe

Crop transport: - Head, wheel barrow

New mechanisation options

Animal Draft based systems – Maize, sorghum, sunflower, groundnuts, and sweet potato.

(AD- Animal Drawn: TD- tractor drawn)

Primary tillage: - AD reversible mouldboard plough OR ripper tine for minimum tillage operations in which soil inversion is not required.

Seed bed preparation: - AD tooth harrow for crops planted on the flat (maize, sorghum, sunflower, groundnuts) OR a combination of AD harrow and AD ridger for root crops (Irish and sweet potatoes)

Seed establishment:-For crops planted on the flat (maize, sorghum, sunflower, and groundnuts) - AD planter OR AD ploughs at shallow depth, dropping seed by hand and covering with AD harrow.

For root crops a combination of a hoe and hand planting.

Crop maintenance:-

Weed control

For maize, sorghum, sunflower, groundnuts use of an AD cultivator inters row and manual weeding with a hoe in row. OR application of herbicides with a knapsack sprayer OR manual weeding with a hoe.

For Irish and sweet potato use of a ridger to weed sides of ridges and hand hoe along top or ridge Or herbicide application with a knapsack sprayer.

Fertiliser application

Basal dressing for Maize, sorghum, sunflower and groundnuts is applied by planter or manually into the planting furrow after furrow opening with a plough.

Top dressing is done manually for all crops.

Crop harvesting:-

Maize –Use of a machete or hoe to cut stem and then piling up of the plants in the field in the form of a stook to dry further in field.

Sorghum – use of knives to cut head manually

Sunflower- Use of knives to cut sunflower head manually

Groundnuts – Use of AD groundnut lifter (an attachment which can be fitted to a plough beam in place of the plough mouldboard) or use of hoes.

Crop transport: - Animal drawn cart. Head, wheel barrow

Conventional tractor based systems Maize, sorghum, sunflower, groundnuts, Irish potato, and sweet potato.

Primary tillage: - TD disc plough OR ripper tine for minimum tillage operations in which soil inversion is not required.

Seed bed preparation: - TD disc harrow for crops planted on the flat (maize, sorghum, sunflower, groundnuts) OR a combination of TD disc harrow and TD ridger for root crops (Irish and sweet potatoes)

Seed establishment:-For crops planted on the flat (maize, sorghum, sunflower, groundnuts) - TD planter.

For root crops a combination of a hoe and hand planting.

Crop maintenance:-

Weed control

For maize, sorghum, sunflower, groundnuts use of a TD cultivator inters row and manual weeding with a hoe in row. OR application of herbicides with a boom sprayer

Or herbicide application with a boom sprayer

Fertiliser application

Basal dressing for Maize, sorghum, sunflower and groundnuts is applied by planter at time of planting or with an oscillating sprout spreader.

Top dressing is applied with an oscillating sprout spreader.

Crop harvesting:-

Maize –Combine Harvester OR use of a machete or hoe to cut stem and then piling up of the plants in the field in the form of a stook to dry further in field.

Sorghum – Combine harvester OR use of knives to cut head manually.

Sunflower- Combine harvester OR use of knives to cut sunflower head manually

Crop transport: - tractor drawn trailer.

Banana

Primary tillage -Use of ripper followed by a disc plough at 300mm depth. For banana, a second ploughing operation at 3 weeks is required.

Seedbed preparation-Hole digging is manual for banana

Crop maintenance-Use of mist blowers for application of pesticides

Manual application of fertilisers

Crop harvesting-Manual harvesting

Annex 4. Proposed Agricultural Mechanisation Systems for Marshlands¹²

Land slope flat

Field dimensions: plot widths currently up to 20m

Plot lengths currently are varied but may reach 25m

Plot shape : irregular. The shape is created by drainage around the plot.

Provinces with these land forms:-All

Crops

Rice

Current mechanisation options for rice

Primary tillage: - hoe if ground is soft or pick for hard soils

Seed bed preparation: - hoe to pulverise and level the soil

Seed establishment: - transplanting by hand

Crop maintenance: - use of a small narrow hoe for first weeding and uprooting of weeds by hand for second weeding.

Crop harvesting: - sickle

Crop transport: - Manual or on bicycle

Use of herbicides for crop maintenance would speed up the weeding operation in rice but this appears undesirable as the marshlands are part of a delicate eco-system and in cases serve as a source of drinking water for humans and livestock.

New mechanisation options

Primary tillage: - Use of AD plough

Seed bed preparation: - Use of a single axle tractor with a rotavator

Seed establishment: - Manual transplanting or rice trans-planter

Crop maintenance: - Use of selective herbicides

Crop harvesting: - Use of a single axle tractor with cutter bar mower mounted in front, reaper & binder or combine harvester

Crop threshing: - Diesel or electrical powered rice thresher.

Crop transport: - AD cart or tractor trailers

Annex 5. Proposed Agricultural Mechanisation Systems for Wet Lands in Valleys¹²

(Similar to marshlands but with limited water resources not capable of supporting rice production)

Land slope flat

Field dimensions: plot widths currently up to 20m

Plot lengths currently are varied but may reach 25m

Plot shape : irregular. The shape is created by drainage channels around the plot.

Districts with these land forms: - Southern and Northern Provinces. Isolated pockets in Northern and Eastern Provinces

Crops

Maize and beans

Current mechanisation options for maize and beans

Primary tillage: - pick, mattock, hoe

Seed bed preparation: - hoe

Seed establishment: - ?????

Crop maintenance: - manual

Crop harvesting: - sickle

Crop transport: - Head, wheel barrow

New mechanisation options

Primary tillage: - Use of AD plough or TD plough

Seed bed preparation: - Use of AD harrow or TD rotovators

Crop establishment: - Use of AD planter OR AD plough (at a shallow depth) manual dropping of seed and covering with AD harrow.

Crop maintenance: - Use of AD cultivator inters row and manual weeding in row OR use of herbicide with knapsack sprayer.

Crop harvesting: - Use of AD reciprocating cutter for Soya beans. Use of hoe or machete for maize

Crop transport: - AD cart or tractor trailers

If the wet lands can be drained to support tractors at the beginning of the season, then treat terrain as flat dry land and adopt use of tractors. Minima have succeeded in doing this.

Annex 6. Proposed Agricultural Mechanisation Systems for Slopped Land (slope>20%)¹²

Land specifications

Land slope >20% with no terracing
Field dimensions: plot widths varied from as low as 5m
Plot lengths varied from as low as 50m
Plot shape : curved and irregular

Districts with these land forms:-North and Western provinces

Crops: maize, Soya beans, cassava, sweet potato, Irish potato, sunflower, groundnuts

Banana, tea, coffee

Current mechanisation options

Current mechanisation options for maize, Soya beans, groundnuts, sunflower, Irish potato, sweet potato

Primary tillage: - pick, mattock, hoe

Seed bed preparation: - hoe, harrow, shovel (for root crops)

Seed establishment: - hoe

Crop maintenance: - hoe, knapsack sprayer (for herbicides)

Crop harvesting: - machete, hoe

Crop transport: - Head, wheel barrow

Current mechanisation options for coffee, tea and banana.

Soil loosening across field –pick, mattock, and hoe

Second soil loosening (after three weeks)-hoe

Hole digging (600mm diameter and 600mm depth) at a 3*3m spacing for banana and 2*2m for coffee-pick, mattock, and hoe

Soil/manure mixing to a depth of 300mm

Placement of tuber-manual labour

Covering of tuber with 50mm of soil- hoe/shovel

Mulching – use of machete to cut loose banana stalks

Pesticide application- knapsack sprayer

Harvesting-machete

Note: Soil loosening is only done in first year for the tea, coffee and banana crops. Thereafter, the crop only requires minimal weeding if the ground is covered with mulch.

New mechanisation options

Lands in mountainous parts of the country (Northern and Western provinces) have a combination of shallow slopes (Near the valleys and at the top) and steep ones in between.

Slopes 0-5% treat as cropping on dry flat land

Slopes 5-12%- Treat as land with shallow slopes land but with special attention to conservation works such as contours

Slopes in the range of 12 to 55% terrace then adopt mechanisation options for terraced lands.

Proposals to reduce mechanisation requirements on steep parts of the slopes

The strategy for cropping on steep slopes should not only consider mechanisation. The first alternative option is to consider adoption of land use systems that do not require seasonal land preparation. Lands planted with bananas, coffee have been known to have gone for 20-30 years without being ploughed up. With mulching recommendations, soil loss levels have been reduced to acceptable levels and weed control requirements are limited. Tea produces a dense canopy that reduces rain drop impact on the soil to levels that drastically reduce erosion levels. The three objectives of generating income from the farmer, foreign currency for the country and minimising soil erosion levels are achieved without the need for mechanisation inputs seasonally for primary tillage, seedbed preparation and crop establishment and weed control.

The second and perhaps more challenging proposal is to investigate minimum or zero tillage options which can be applied to crop production on steep slopes. By minimising the requirement for initial land preparation (ploughing and seedbed preparation), farmers are able to establish their crops early and hence potentially achieve better yields.

The third recommendation is for the terracing programme to be speeded. There are sections of these slopes where animal draft could be used to speed up the process. Terracing essentially involves soil loosening, shifting of the top soil, flattening of land and then putting back of the top soil. Use of the animal drawn plough, for soil loosening, on slopes animals can negotiate and the animal drawn dam scoop, for soil movement, could be used to speed up the current system which relies totally on manual labour.

Annex 7. Comparative Work Rates ¹²

Comparative work rates
(in maize with a row width of 0.9m)

Operation	Working width m	Working speed m/s	Field efficiency	Work rate Ha/h	Work rate h/ha	work rate days/Ha	Relative capacity
Ploughing							
Manual					270	45	1
Animal	0.2	1	0.8	0.1	17.4	3	15
Tractor	0.9	1.2	0.85	0.3	3.0	0.34	134
Planting							
Manual					30.0	5.00	1
Animal	0.9	1	0.75	0.2	4.1	0.69	7
Tractor	2.7	1.3	0.8	1.0	1.0	0.11	45
Cultivation							
Manual						35	1
Animal	0.9	1	0.8	0.3	3.9	0.64	54
Tractor	2.7	1.4	0.85	1.2	0.9	0.14	243
Spraying							
Manual	0.9	1.2	0.75	0.3	3.4	0.57	1
Animal		no c					
Tractor	12	1.4	0.75	4.5	0.2	0.03	21

Notes:

Manual work rates were those provided by farmers with the exception of the spraying operation which is calculated.

Assume 6 hours per working day for manual labour and animals.

Tractors are worked for 9 hours per day

A mechanical planter is used with the animals