Funded by the Ministry of Agriculture, Forestry and Fisheries of Japan

Feasibility Survey Project on Agricultural Mechanization for the Small Scale Farmers in Sub Sahara Africa
-Acceleration of Agri-Business -

Final Report –Third Year-

March 2016

JAICAF ジェイカフ

Japan Association for International Collaboration of Agriculture and Forestry

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Printed in Japan by Shokou Insatsu Ltd.

Preface

In East Africa, the rapid population growth is causing a quantitative expansion for the demand of food, and the production of rice and wheat cannot keep up with demand due to the change in people's taste. There are various factors to the problem, but their inability to free many farmers from agriculture depending on rainwater and human power is an obstacle. The mechanization of agriculture is noted as one of ways to overcome this difficulty.

Based on the circumstances, we, JAICAF, with subsidies from the Ministry of Agriculture, Forestry and Fisheries of Japan, have been implementing "Feasibility Survey Project on Agricultural Mechanization for the Small Scale Farmers in Sub Sahara Africa" since 2013 to implement an agricultural mechanization feasibility test for small scale farmers and survey of the current state of mechanization.

Up until now, this project has been expanded to cover Uganda, Tanzania and Ethiopia, and in FY 2015 (the final year of the project) we tested the introduction of power tiller and a combine harvester as part of the Mwea Irrigation Scheme in Kenya, and implemented tests to assess labor productivity and cost, etc.

In the final year of the feasibility survey project in the target region of Mwea, it was found that not only is preparation activity already expansive and being controlled with large machinery, but from the soil environment of the Mwea Irrigation Scheme there were noticeable issues with the use of power tillers. On the other hand, as far as upland crop farms in the surroundings are concerned, there is great potential for mechanization with power tillers that can be used for multiple purposes, and demonstrations carried out as awareness programs for power tillers and de-stoner for use with rice were well received. The agricultural funding environment is also maintained at a higher level than in surrounding countries, and agricultural mechanization is expected to progress going forwards as in the countries surveyed to date, such as Uganda and Tanzania.

In this report, we put together the outline and the results of the above-mentioned activities in the third year of this project as a final report. We expect that our project results will contribute to the mechanization of the region and also be utilized by private companies as well as international cooperation related parties. We will be pleased if our report is of help to those concerned.

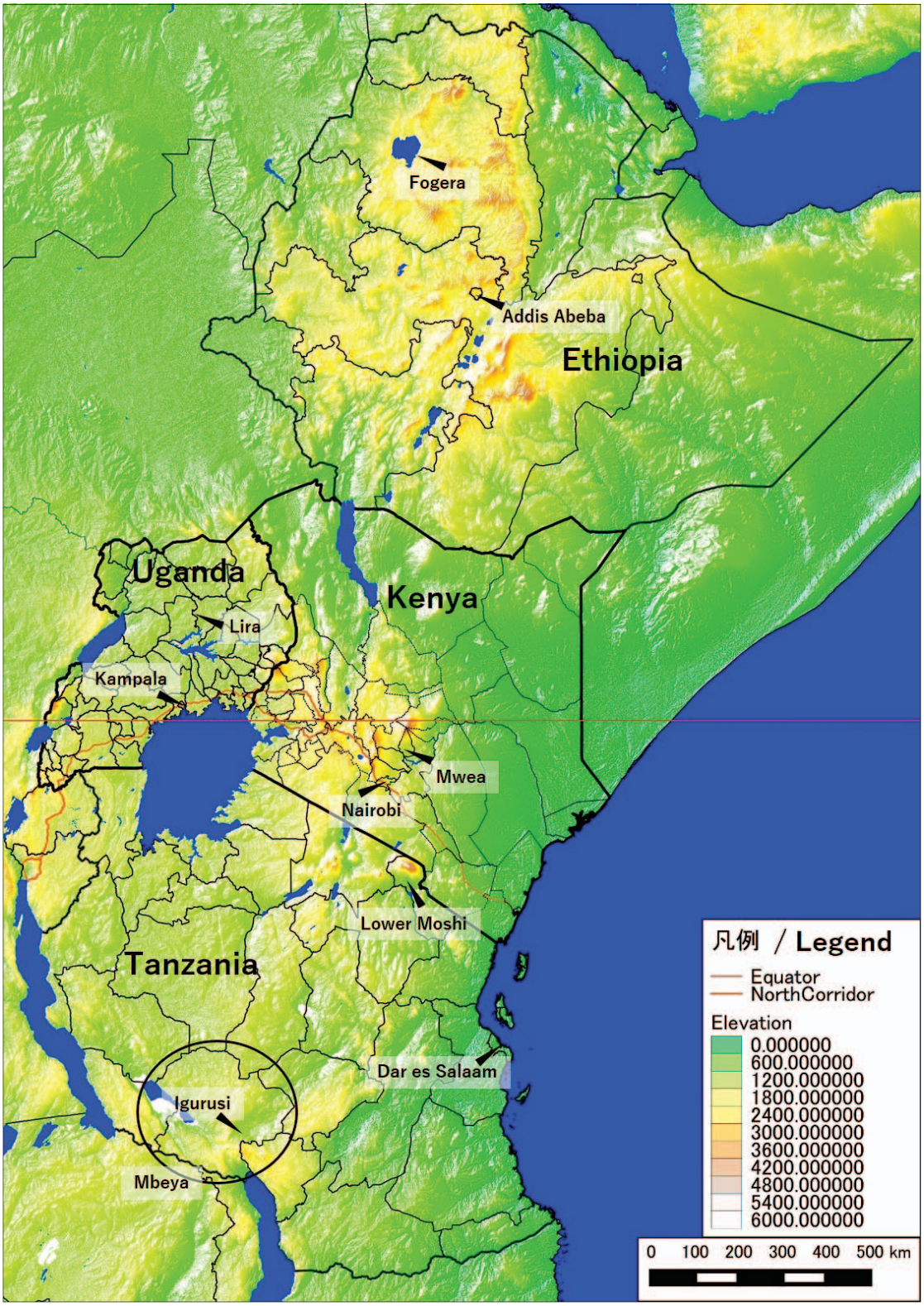
To implement and operate this project, we received a large amount of support from each specialist dispatched to the site. Also, the expert committee which was separately established in JAICAF headquarters gave us guidance and advice on planning of this project and the evaluation study. Furthermore, for the activities by our specialists in the

countries concerned, we received cooperation from many organizations: in Uganda, the Japan International Cooperation Agency (JICA) Uganda Office and JICA PRiDe Project; in Tanzania, the JICA Tanzania Office and JICA TANRICE2 Project; and in Kenya, the new JICA Kenya Office and the Rice-based Market-oriented Agricultural Promotion Project (RiceMAPP). We deeply appreciate their cooperation.

Lastly, we wish to make clear that this report was made based on our association and does not represent the opinion of the Ministry of Agriculture, Forestry and Fisheries and the Japanese Government.

March, 2016

Ryuzo Nishimaki, President
Japan Association for
International
Collaboration of Agriculture
and Forestry



Project Activity Map

Source : Javis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (http://srtm.csi.cgiar.org)

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Abbreviations List

Abbrebiations	Standard name
AFC	Agricultural Finance Bank
AfDB	African Development Bank
ASAL	Arid and Semi-Arid Lands
ASDS	the Agriculture Sector Development Strategy
ASDSP	Agricultural Sector Development Support Programme
C/P	Counterpart
CIMMIT	International Maize and Wheat Improvement Center／ Centro Internacional de Mejoramiento de Maíz y Trigo
ERS	the Economic Recovery Strategy for Wealth and Employment Creation
FIDA	Federation of Women Lawyers in Kenya
FVC	Food Value Chain
IDRC	International Development Research Centre
ILRI	International Livestock Research Institute
JICA	Japan International Cooperation Agency
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KALRO	Kenya Agricultural and Livestock Research Organization
KATC	Kilimanjaro Agricultural Development Project
MIAD	Mwea Irrigation Agricultural Development Centre
MoALF	Ministry of Agriculture, Livestock and Fisheries
MRGM	Mwea Rice Growers Multipurpose Cooperative Society Ltd
NaCRRI	Namulonge Crops Resource Research Institute
NALEP	The National Agriculture and Livestock Extension Programme
NIB	National Irrigation Board
NRDS	National Rice Development Strategy
PEGRES	Project on Enhancing Gender Responsive Extension Services in Kenya
RiceMAPP	Rice-based and Market-oriented Agriculture Promotion Project
SIDA	Swedish International Development Cooperation Agency
SRA	the Strategy for Revitalizing Agriculture
SSA	Sub-Saharan Africa
UNECA	United Nation Economic Committee for Africa
UPAP	Urban and Periurban Agriculture Project

Exchange Rate

US Dollar (USD) :
  1 Yen = 114.1USD
Kenyan Shillings (Ksh) :
  1Ksh = 1.126 Yen
Ugandan Shillings (Ush) :
  1USD = 0.034 Yen
Tanzanian Shillings (Tsh) :
  1Tsh = 0.052 Yen

Source : JICA Foreign Currency Rate (2016 March)

(http://www.jica.go.jp/announce/manual/form/consul_g/ku57pq00000kzv7m-att/rate_2015.pdf)

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Chapter 1 Project Report Summary

1. Objectives of Project

A large number of people in the Sab-Saharan region are undernourished, which accounts for approximately 30% of the total population. In recent years, rises of international food prices have seriously exacerbated the problem of poverty and hunger in the region. To solve this problem, it is important to ensure food security and reduce poverty. If a direct investment in agriculture, which is a key industry in the region, successfully helps increase agricultural production and productivity, it will be a good measure for solving the problem.

In view of the foregoing, this project implemented demonstrative experiments in which machinery and resources, such as agricultural machines, were input to agriculture in the Sub-Saharan region to increase agricultural production and productivity. The purpose of the project is to promote private investments in agribusinesses of farmers in this region through experiments, which aims at increasing the income of agricultural households and reducing poverty in the region.

2. Contents of Project

1) Overview

The Feasibility Survey Project on Agricultural Mechanization for Small Scale Farmers in Sub Sahara Africa of Fiscal 2015 (hereinafter, called “Project”) is a part of the project that has continued from demonstrative experiments for agricultural mechanization and a related survey implemented in the Sub-Saharan region in Fiscal 2013. For Fiscal 2015, which is the third, and final year, of the project, we selected Kenya for such demonstrative experiments, followed by Uganda in Fiscal 2013 and Tanzania in Fiscal 2014. As for the related survey, we conducted it in Ethiopia in Fiscal 2014, in addition to Uganda and Tanzania, to collect information that may relate to agricultural mechanization. We also conducted it in Kenya in Fiscal 2015.

2) Feasibility trial and survey

In agricultural villages in which agricultural machines might become more widespread, we conducted a model experiment for building agribusinesses that could help increase the income of agricultural households and reduce poverty through agricultural production, processing and sale by introducing agricultural machines (mainly machines with motive power), and resources to be used by farmers experimentally.

More specifically, we focused on the Mwea Irrigation Scheme, which supports half of the rice production of Kenya, and studied the status of agricultural mechanization in the Irrigation area. We implemented a demonstrative experiment in which power tillers were used for land preparation, and combine harvesters for harvesting and threshing, in place of manual labor and other current ways of farming, and compared experimental agricultural work with traditional work in terms of labor productivity and costs.

3) Demonstration of agricultural machineries

Considering the features of the Mwea Irrigation Scheme area (in terms of the level of agricultural mechanization and soil environment), we also paid attention to upland crop fields in which power tillers might be useful, and held a power tiller demonstration event for such upland farmers in Kirinyaga County, which includes Mwea, to explore the possibility of introducing these machines in crop fields. At the same time, we hold an event to demonstrate a de-stoner for rice in Mwea. For this event, we transported to Mwea a prototype de-stoner that Hosokawa Works, Co., Ltd., a Japanese agricultural machine manufacturer, had made in Uganda according to specifications adapted to the local conditions. In addition, we held a second power tiller demonstration event for vegetable farmers in a suburb of Nairobi.

3. Summary of Results

1) For the use of, mainly, power tillers for land preparation in rice paddy fields, the labor productivity (work time) was 2.7 times as high as that of manual labor. For the work of large tractors, it was 2.87 times as high as that of manual labor. In terms of costs for farmers, the work of power tillers costs 3.54 times less than manpower, and that of large tractors 2.11 times less than manual labor. In addition, if depreciation and repair costs are taken into consideration, the work of the machines would cost 4.6 less than manual work. Thus, the machines have sufficient advantages over manual work.
2) According to the results of 1), power tillers seemed to have a good advantage over large tractors for land preparation, which are mainly used in Mwea for that work by hire service. However, the work time of the latter used for comparison include the time of levelling by Oxen and removing residues by manpower after the machine work, and in a comparison in terms of simple machine work, large tractors were five times as fast as power tillers. In addition, in many cases, agricultural land in Mwea characteristically contains black cotton soil which becomes sticky with moisture penetration, and a power tiller can easily sink in the ground because its tires are narrow and have a small area. So, ploughing with a power tiller requires operational skill.
3) Considering the conditions of 2), for land preparation, power tillers may not be competitive with large tractors which are mostly used in Mwea. Power tillers, however, have an advantage in that they can be used in various ways (e.g., transportation, and providing power to a water pump, an agricultural processing machine, etc., by connecting to them). They may well become more widespread among upland crop field famers. Actually, there are many farmers who grow cash crops, such as tomato, banana and french bean in Kirinyaga County, which includes Mwea, and, in many cases, their field lots are small and not uniform in shape, unlike paddy fields in Mwea. These conditions are to the advantage of power tillers.
4) However, power tillers are not well known in Kenya, and agricultural machinery sales agents, of which there are many in Kenya, mainly deal in large four-wheel tractors, and very little in power tillers. This is a problem to be overcome. In Mwea, there are some farmers who purchased power

tillers which were not from Japanese branded manufacturers, and used them for tilling and transportation, but could not obtain maintenance service or replacement parts when they had failures, and could no longer use them three years after purchase.

5) Under these circumstances, the power tiller demonstration events were really meaningful. In the Project, we held such an event for upland crop field farmers, in Kirinyaga County, and for vegetable farmers in Nairobi. In the events, there were many farmers who said that they would like to buy and use power tillers; however, those who could actually buy and maintain such expensive machines might only be cash crop farmers who earned enough for them.

   In addition, the results of our research on agricultural finance show that there are relatively many financial services to assist purchase of agricultural machines. However, from a small-scale farmers' perspective, how to access such services is not known.

6) Thus, holding events for supporting access to financial services, while demonstrating the use of power tillers, would help promote agricultural mechanization of small-scale farmers. In the present situation, it would be difficult for such farmers to buy power tillers made by Japanese branded manufacturers. However, we found some local businesses holding such events, and it can be expected that mechanization will take place in the near future.

7) In the Project, in addition to the abovementioned events, we arranged demonstrations of the prototype de-stoner that Hosokawa Works, which had participated in the survey team, made in Uganda to adapt to local conditions. The results of our research in rice mills in Mwea show that added value by de-stoning was hardly appreciated. However, it is women in most cases who do the work of de-stoning, and so, the de-stoner was favorably received by women. Accordingly, it may be important to raise people's awareness of not only the value added by de-stoning, but also an increase of leisure time for women by shortening their work with mechanization, which would have a good social impact.

8) In the survey, we came to know that combine harvesters had been recently introduced in the Mwea Irrigation Scheme. The combine harvester mechanizes both harvesting and threshing. It improved labor productivity by as much as 60 times compared to traditional manual work, and the cost for farmers was almost the same. Mwea often has rainfalls in the harvesting season, and their ability to harvest quickly at an appropriate timing affects the quality of rice that they can achieve through the post-harvesting process. Therefore, there seems a great demand for this machine among farmers. We recognized that there were some 15 Japan branded combine harvesters, and some 60 to 70 made in China, working in Mwea. In view of the total capacity, the needs in all the fields in Mwea seem to be met. The results of our research on farmers, however, show that all farmers who need combine harvesting work could not obtain combine harvester hire services.

9) We conducted follow-up research and tests on countries in which we implemented the Project. For Uganda, we found that upland rice farmers who had purchased used Japan branded power tillers secured good earnings after expenses deducted from their rice growing, and providing power tiller hire service and sowing service to neighborhood farmers. One problem to be solved is that of

maintenance. They are now supported by an agricultural machinery research institute in Uganda. A new agricultural machinery sales agent is considering a sales strategy, and maintenance service may be improved in the near future. If this successful case of upland rice farmers, which was a pilot case, becomes widely known, it may be expected that power tillers would become more widespread in the future.

10) We also conducted such follow-up research and tests in Tanzania. In Mbarali District, Mbeya Region, where there are many traditional and modern irrigation schemes, Japan branded power tillers have already been sold and come into common use. We extracted some 50 power tillers from among them for research. The time of our research was in a season when there is a great demand for transportation services. Thus, we could see many cases of actual transportation by power tillers, and found that eight bags or so of rice in the husk, each with a weight of 80 kg, were loaded on the trailer and transported over a distance of 30 km per day. Some operators transported over a distance of 70 km or more per day. Thus, the power tiller has a good advantage in Mbarali District where there are scattered irrigation schemes, unlike Mwea in Kenya.

11) In view of the foregoing, it can well be expected that small-scale farming will be mechanized mainly with power tillers in the Sub-Saharan region, although there are different ways of using them from place to place, and it is necessary to devise effective ways of promoting their general use. In the field of post-harvesting processing, we undertook activities to support the efforts of Japanese private corporations to engage in business in Africa. We hope that our policies and ideas will help them to enter African markets in the future.

Chapter 2 Feasibility Survey on Agricultural Mechanization in Kenya

1. Kenya's history, politics, society and economy

1) History

While it is said that, far back around 2000 B.C., Cushites came from northern Africa to where Kenya now stands, the current Kenyan people are basically made up of Bantu and Nilotic peoples who moved there in 1000 B.C. or later. Today, 42 ethnic groups are believed to live in Kenya, and the five major tribes of Kikuyu, Luhya, Kalenjin, Luo and Kamba account for two-thirds of the entire population of the nation. Although the Kikuyu is the largest ethnic group, it accounts for just 17.2 percent of the entire population. In case of political disputes, the other tribes most frequently confront the Kikuyu together.

Around the eighth century, Arabs settled in the coastal areas and established cities such as Mombasa and Malindi as trade centers. The Swahili language was formed based on the Bantu language and Arabic by the 10th century, enabling the Swahili culture to thrive there. Arabs expanded to inland areas around the 18th century, with the Empire of Oman taking Mombasa in 1828. Kenya was colonized during the 19th century. Although Britain and Germany initially advanced into the state, Britain finally won the power struggle with Germany. In 1902, Kenya, along with Uganda, became a British protectorate. Under British rule, railways and other infrastructure facilities were installed, while administrative systems, agricultural experiment stations, the agricultural extension worker system and other new set-ups were also introduced.

Kenya became independent as part of the British Commonwealth of Nations in 1963 and became a republic the following year. Jomo Kenyatta was then appointed as the first president of the Republic of Kenya. Kenya initially implemented socialist policies due to its anti-colonial stance, like other African nations.

2) Politics

Kenya has a presidential government. Its parliament has 224 seats with the tenure of office being five years. A bicameral system was introduced in 2013. In 2010, a referendum was carried out, and the new Constitution was enacted. While Kenya used to be based on centralism and comprise eight provinces, decentralization has been promoted and the country has been divided into 47 counties. Many authorities, funds and personnel have been transferred to those counties. The counties are further divided into sub-counties, wards, villages and other administrative districts.

3) Society

Area: 580,000 square kilometers/Population: 45 million/Per capita GDP: US$ 1,800

Official language: Swahili, English

Tribes: Kikuyu, Luhya, Kalenjin, Luo, Kamba, Somali, Kisii, Mijikenda, Meru, Turkana (There are also big landowners of British origin as well as people of Indian origin who have excellent commercial skills, though the populations of those people are relatively small)

Religion: 47.7% regard themselves as Protestant; 23.5% as Catholic; 11.9% as followers of other Christianity; 11.2% as Muslim; 1.7% as worshipers of indigenous beliefs; others as belonging to Hindu and other religions.

Education: The 8-4-4 public education system, which consists of eight years in elementary school, four years in middle school and four years in high school, has been adopted since 1985. The elementary schooling has been provided for free since 2003, helping raise the quality of human resources in Kenya, though some problems have been reported with the system. In addition, while just 10,000 people entered national and other public universities in 2000, the number reached 24,000 in 2010, indicating the education level of the country has increased. One problem is that the employment rate after graduation has yet to start rising. While 82.8 percent of children attend elementary school, the enrollment rate for middle school and high school are 50 percent and 4.0 percent, respectively. The enrollment ratio is not significantly different between male and female children.

4) Economy

A major industry of Kenya is agriculture, which accounts for 30 percent of the gross domestic product (GDP) and 65 percent of the total exports. It is also estimated that 70 percent of working people in Kenya are engaged in agriculture. The country has experienced significant industrialization compared with other Eastern African nations. Its manufacturing industry has undergone an especially remarkable growth. Meanwhile, as for the mining industry, fewer types of minerals are found in Kenya and the mining output is relatively small. Exports to Japan are worth US$ 46 million, while imports from Japan are valued at US$ 911 million. Major exported goods are plant materials, coffee, tea, spices and food products. Key import items are transport machinery, steel and general machinery.

There is the Japan Chamber of Commerce and Industry in Nairobi. From the viewpoint of food value chain, Japan's food and agricultural machine-related companies have recently been expanding to Kenya aggressively. Examples of the upstream companies in the value chain that have expanded to Kenya include Toyota Tsusho Corporation, which has established the Toyota Kenya Academy (TKA) to offer training on operations of tractors and other agricultural machines, and Kubota Corporation, which helps Car & General Ltd. promote the sales of small tractors intended for horticulturists and other farmers though most of local farmers use large tractors.

Meanwhile, downstream firms working in Kenya include the Nissin Foods Group, which was engaged in academic-industrial research with Jomo Kenyatta University of Agriculture and Technology (JKUAT) to develop new products; Toridoll Kenya Ltd., which has succeeded in selling the "teriyaki lunch box" in Nairobi's central business district and is currently looking to increase the number of its shops; and AfricaScan Inc., which conducts marketing surveys in rural areas where horticulture is popular while running kiosks in such regions.

Table II.1.1 Japan's assistance for Kenya by support category

(Unit: billion yen)

Fiscal year	Yen loan	Grant aid	Technical assistance
FY2009	29.516	4.296	2.711
FY2010	25.586	3.882	3.026
FY2011	-	6.584	4.999
FY2012	27.691	3.969	3.619
FY2013	-	0.419	3.390
Total	298.513	1,119.729	109.161

Japan's major assistance activities in agriculture and forestry are as follows:

Jomo Kenyatta University of Agriculture and Technology (JKUAT)

Construction of grain storage facility

Mwea Irrigation Development Project

Development of national floriculture center

Construction of forestry and seedling cultivation training center

Social Forestry Training Project

Kenya Baringo development project

Small vegetable farmer development project (SHEP → SHEP PLUS → SHEP UP)

2. Agriculture and agricultural policies

1) Natural features

Kenya stretches 5 degrees north to south with the equator at the center and lies between 34 degree to 42 degree East longitude. Lake Turkana is located at the center of the northern part of the country, desert areas surrounding the lake. In the eastern part of the state, a semi-arid region stretches toward the coast (coastal areas, however, belong to tropical climate and have a lot of rainfall). In the meantime, the central area of the western part of Kenya is a highland about 2,000 meters above sea level and has relatively high rainfall. That arable land has been seized by authorities from people in arrears since the colonial period. However, the 60-kilometer-wide part of the Great Rift Valley runs through its center, which is an Arid and Semi-Arid Land (ASAL) that is situated at a low altitude and has low rainfall. Based on the precipitation and the elevation, Kenya can be categorized into the following seven climatic zones:

① Coastal tropical zone: There are no dry seasons and it rains most in May and October. The temperatures and humidity are high throughout the year.

② Kenya's tropical highland zone: Although it is located right on the equator, the area is a highland so the climate is cool. The amount of rainfall greatly varies depending on the region.

③ Tropical zone in Lake Victoria basin: As there is a lake in the zone, there are no dry seasons there. However it does not have high rainfall, and the temperatures are not high.

④ Northwestern tropical zone: It is located on a highland near the border with the northeastern part of Uganda, so the temperatures are not high.

⑤ Southern tropical zone: It is a small area linked to the central part of Tanzania and can be divided into two regions in Kenya: Narok County and southern Taita County/Kwale County areas. It is on a highland so the climate is comfortable compared with surrounding semi-arid areas.

⑥ Eastern semi-arid zone: The vast land has a mean annual precipitation of ≤ 500 millimeters. The average temperature is high, ranging from 22 to 27 degrees Celsius.

⑦ Central northern arid zone: It is an arid zone that receives ≤ 250 mm of rainfall.

2) Terrain

In the northern and eastern part, from highest park in this country, Mount Kenya, flat land which is less than 600 m spread wildly and end to the Indian Ocean. In south and eastern part, there is relatively hilly area. Even if Nairobi, the Capital city of Kenya, it elevation is more than 1,600m. On the contrary, irrigated rice cultivation area, like Mwea and Kisumu, these land is sunken, which is suitable for cultivation of irrigated rice (Figure II.1.1).

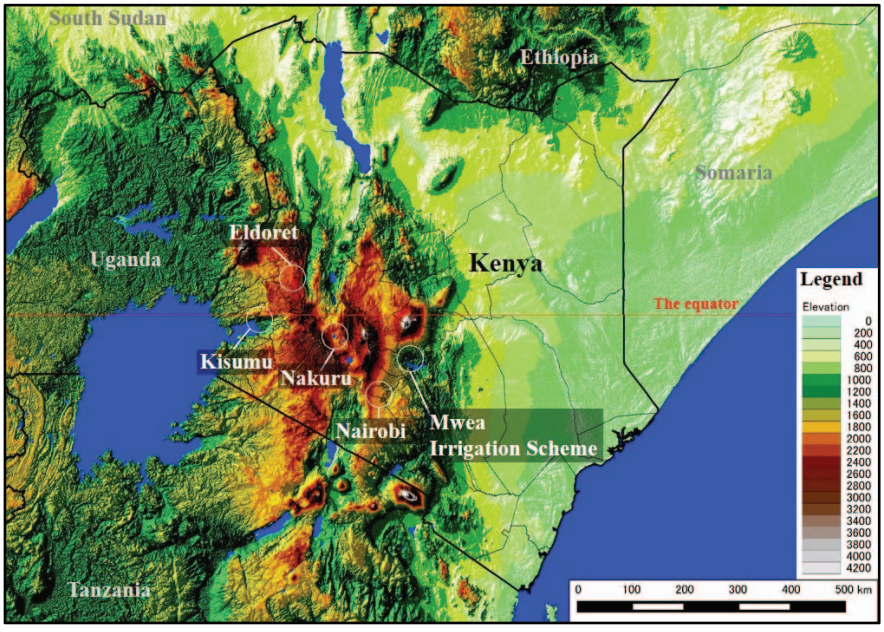

Figure II.1.1 The Terrain of Kenya

Source: Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (http://srtm.csi.cgiar.org)

3) Agriculture

Corn, beans, wheat and rice, as well as the banana and sweet and white potatoes, are common crops produced in Kenya. While tea, coffee, sisal and cotton are famous as goods that have traditionally been exported from the state, flowering plants and vegetables intended for European and Arabic countries have recently come to account for a large portion of its exports. Many domestic animals, such as cattle, sheep, goats and poultry, are also raised. Few draft animals are used in Kenya.

A small-scale farmer typically owns 1 to 2.5 hectares of land, but in highlands and other densely populated areas, such a farmer owns less than 1 hectare of land. In semi-arid and other regions, land is typically owned by the local communities, not by individuals, and people pasture animals in those areas.

Meanwhile, large farms own 50 hectares or more of farmland, which were primarily ceded to white people as "White Highlands" under colonial rule. Depending on the climate of the region, such white people operated various facilities such as (1) plantations to grow coffee, tea, sisal, wattle (a kind of acacia) and other perennial crops; (2) mixed farms that mixes the cultivation of wheat, corn, sunflowers, pasture and other crops with the dairy farming at the same time; and (3) stock farms to raise beef cattle and sheep.

In the 1960s, most of those white farm operators washed their hands of the business as Kenya was to become independent soon at the time. Since 1962, the Kenyan government has been urging Kenyan farmers to engage in agriculture again in lands purchased from white farm operators with the financial assistance of Britain, West Germany, the World Bank and other parties. The gap between those large farmers and small farmers still remains a huge problem in Kenya's agriculture. For example, while large-scale farmers use a lot of irrigation water to grow flowers and vegetables in greenhouses and to directly export them to Europe, small farmers have to cultivate those plants with no such equipment and machinery.

Agriculture heavily relies on rainwater. Kenya can meet almost all of its own demands when it has high rainfall, but 30 percent or more of crops consumed in the state are imported from other countries in a year of drought.

There is limited irrigated land in Kenya. Major irrigation schemes are shown below.

Table II.2.1 Major irrigation schemes

Project name	Region	Water source	Scale	Crops to be grown
Perkerra Irrigation Scheme	Rift Valley	Perkerra River	3,000 ha	Onion, chili, watermelon, papaya
Mwea-Tebere Irrigation Scheme	Central area	Nyamindi River Thiba River	13,000 ha 6,400 ha already developed	Rice
Bura Irrigation Scheme	Coastal area	Tana River	2,500 ha	Cotton, corn, tomato, onion
Tana-Hola Irrigation Scheme	Northern coastal area	Tana River	4,800 ha 900 ha already developed	Cotton, peanut, cowpea, corn
West Kano Irrigation Scheme	Western area	Lake Victoria basin	2,200 ha	Rice

4) Agricultural policies

Immediately after its independence, from 1963 to the 1980s, Kenya's agricultural policies were deeply influenced by the government's stance of putting emphasis on sovereign independence and economic development, and were primarily designed to improve land productivity by encouraging small farmers to acquire more land. During that period, the government intervened in even the shipment and the setting of retail prices of basic agricultural products (such as the corn, corn flour, sugar cane, sugar, wheat, flour, bread, milk and dairy products). For that purpose, the state established public corporations and encouraged the formation of agricultural cooperatives. Investments were also made in infrastructure facilities, including irrigation facilities and farm roads. The basic goal of the agricultural policies at the time was to achieve food self-sufficiency. However, due to the non-transparent management of public corporations, the low quality of farmer services, the market monopoly and other negative factors, those efforts could not produce good results.

The era of liberalization that started in the mid-1980s is characterized by the "structural adjustment program" and "free markets," which were introduced under pressure from the International Monetary Fund (IMF), the World Bank and other outside parties. During the period, various policies, such as privatization, relaxation of regulations, removal of trade barriers, introduction of the floating exchange rate system and decentralization, were put up. But such moves made no achievement but the abolishment of inefficient public corporations, and provided no evidence that the promotion of market liberalization had produced sufficient effects.

In 2003, the new administration announced an economic recovery plan based on the creation of wealth and employment that is known as the Economic Recovery Strategy for Wealth and Employment Creation (ERS). Under the plan, Kenya put its top priority on agriculture, along with trade, industrialization and tourism development, in promoting economic growth, and compiled the

Strategy for Revitalizing Agriculture (SRA) as the basic agricultural development program for the 2004-2014 period.

Unlike the past projects, which were intended to achieve food self-sufficiency, the SRA placed emphasis on the commercial benefits, markets and profits in improving agriculture, and was designed to ensure food security by fulfilling those goals. The SRA also states Kenya would adopt a cross-sectional approach and promote cooperation between the public and private sectors in the field of agriculture. On that basis, the SRA sets some goals such as modernization and mechanization of farming, improving agricultural infrastructure, enhancing agricultural services and improving access to markets in and outside Kenya. Thanks to those policies, the growth rate for the agricultural sector drastically rose to 6.3 percent from minus 0.3 percent over the 2003-2007 period, exceeding the GDP growth for the same period.

The Kenyan government in 2008 announced Vision 2030. In line with the move, the government revised the SRA and released the Agriculture Sector Development Strategy (ASDS), which covers the period between 2010 and 2020 and is designed to allow the nation to shift from agriculture to achieve self-sufficiency to commercial farming.

5) Administrative organizations

The Kenya Agricultural and Livestock Research Organization (KALRO), which was previously known as the KARI, is the administrative organization engaging in agricultural extension and research. Meanwhile, the National Irrigation Board (NIB) is in charge of the development of irrigation facilities.

6) Agricultural community financing

(1) Finance institution

The AFC (Agricultural Finance Bank), established in 1963, consolidated Land Bank in 1969 and had 40 branches nationwide. It was reorganized into Agricultural Development Bank in 1992. It provided financing to large- and middle-scale farmers, but not to small-scale farmers. In 1965, Co-operative Bank of Kenya was established for small-scale farmers.

According to Central Bank of Kenya, there are 44 organizations that worked as a bank in total (43 commercial banks and 1 real-estate financing company) in Kenya. Among these, 13 organizations are foreign-affiliated. In addition, there are 12 microfinance banks that are engaged in banking under the Microfinance Act 2006 and Microfinance Regulations 2008[1].

(2) SACCO (Savings and Credit Association)

In addition, a financial cooperative association called SACCO (Savings and Credit Association) in Kenya. SACCO enables mutual aid for those who cannot use commercial banks. The association makes a loan to members with something in common (for example, in the same trade or living in the

[1] Central Bank of Kenya Official Homepage (https://www.centralbank.go.ke/)
Last access 2016/02/01 19:05

same area) at low interest rates, who jointly save money. Some SACCOs play a role of a trade association that work together in marketing of products and services without providing such a financing service. SACCOs are classified into Financial SACCOs that provide a financing service and Non-Financial SACCOs that provide no financing service. Financial SACCOs are classified into two types. One is traditional Non-deposit taking SACCOs organized and operated under the Cooperative Service Act (ACT490), another is Deposit taking SACCOs (DTS) organized under the SACCO Societies Act 2008. DTS' provide roughly equivalent financing services. Unlike SACCOs that provide only saving and loaning for mutual aid, they are classified into a formal financial institution.

(3) Mobile banking

The money transfer service using a mobile phone is the most easily accessible among financing services in Kenya. Mobile banking called M-PESA is popular in Kenya. People who have no bank accounts can transfer, save money and make payment using their mobile phones. This service is provided by Safaricom, an affiliated company of Vodafone. M means Mobile and PESA means money in Swahili. Other mobile services available for people with accounts are provided by commercial banks. The services include Mobi-Bank by Kenya Commercial Bank, Pesa Pap by Family Bank, MCo-op Cash by Co-operative Bank and M-Kesho by Equity Bank.

(4) Access to financial services

According to FinAccess National Survey 2013, 32.7% of the population access formal financial services subject to health monitoring such as commercial banks, stock markets and insurance. 65.9% access other financial services that are formal but are not subject to health monitoring. 25.4% access non-financial services. Compared to 31.4% found in the similar survey in 2009, the percentage of the population who access financial services has been increasing. However, one in four still accesses no financial services. Comparing urban and rural areas, 30.6% of the population in rural areas accesses no financial services. The percentage is nearly double of that in urban areas (15.8%).

The mobile financial service is the most frequently used by 59.5% of farmers. Table II.2.2 shows the percentages of the population who access other financial services.

Table II.2.2 Types of financial services used by farmers

Types of financial services	Percentages of the accessing population
Mobile financial service	59.4%
Informal group	31.3%
Bank	24.9%
SACCO	10.0%
Microfinance	3.6%

(5) Finance and agricultural mechanization

Agricultural mechanization requires a relatively large sum of money and long-term financing. Many farmers use loan provided by commercial banks for that. In the field survey conducted in November, interviews with three commercial banks and AFC, a government financial institution were conducted. Table 4 shows financial products available for purchasing agricultural machines.

Table II.2.3 Loan products available for purchasing agricultural machines

Bank	Equity Bank	Faulu[2] Bank	Jamii Bora[3] Bank	AFC
Loan product	Asset management Loan	Asset Management Loan	Agribusiness Loan	Machinery Loan
Percentage of down payment	20%-	10%-	20%-	30%-
Interest[4]	12%	12%	16%	-
Payment period	- 3 years	- 5 years	- 5 years	- 5 years

In addition to these loan products, some banks provide small-scale business loan for processors and distributors and loan products for female entrepreneurs. According to the interviews, Equity Bank and Faulu Bank determine financing based on whether they were negative about financing required for self-sufficient farmers to start shifting to commercial farmers, Jamii Bora Bank took a positive attitude about financing the farmers.

7) Agriculture and gender

Agricultural production in Kenya cannot do without contribution by women. 70% of agricultural production is assumed by women in Kenya. According to the Ministry of Agriculture, Livestock and Fisheries (MoALF), 69% of small-scale farmers in Kenya are women and 80% of labor is assumed by women. However, productivity of female farmers is lower than that of male farmers by about 20-30%. This is caused by land, agricultural materials, agricultural technology and limited access to the market. Women have a limited authority about access to resources and decision making. In order to think agricultural mechanization in Kenya, it is necessary to understand roles of men and women in agriculture.

2 Faulu Bank: Faulu means “Success” in Swahili.
3 Jamii Bora Bank: Jamii Bora means “Better community” in Swahili.
4 Flat rate for the purchase price Interest rates often change. Interest rates are expected to decrease.

ASDS, an agricultural development strategy in Kenya points to promoting gender equality in agricultural development as one of important strategies from the importance of the role played by women in agriculture. For this reason, the government of Kenya requested that of Japan to implement matters to spread efforts of mainstreaming of gender and strengthen capabilities for small-scale farmers. Based on this, JICA conducted the Project on Enhancing Gender Responsive Extension Services in Kenya (PEGRES) from March, 2014 to March, 2016.

One of the most important gender issues in agriculture in Kenya is a difference in access to resources and crushing labor of women caused by division of labor based on gender. Though much of agricultural work is assumed by women, almost all lands and farm animals are owned by men, which make it difficult for women to obtain financial independence. Almost all of reproduction work such as housework and childcare is assumed by women, which makes women poor in time. However, Constitution of Kenya 2010 (CoK 2010), declares gender equity as a basic right, permits equal property right to all people and supports efforts for gender equity in agriculture in Kenya.

Gender issues in agriculture in Kenya, policies and efforts, and issues on mechanization are described.

According to the African Development Bank[5], 80% of self-sufficient food production and 50% of cash crop cultivation are assumed by women. In addition to contribution as labor, the number of women who run farms has been increasing. It is estimated that 40% of small-scale farmers are run by women. Meanwhile, their access to lands, farm animals, information and agricultural materials is extremely limited. In many cases, they cannot control important resources solely without male kins and partners.

Almost all of the most important lands in agricultural production are owned by men. Women in Kenya conventionally access the lands through their male kins. It is rare for women to own their own lands. The new constitution contains gender equity in ownership and land registration and laws on inheritance allow women to inherit lands. However, fewer women are actually shared with lands because of low recognition on gender equity. According to the Federation of Women Lawyers in Kenya (FIDA)[6], only 5% of lands are jointly registered by men and women and only 1% of the total are registered solely by women. This means women who assume agricultural production have no decision right in usage of lands, cannot get loan by mortgaging lands and sell or transfer lands freely.

The second most important resource after land ownership is farm animals such as cattle. Farm animals are important assets to improve agricultural productivity. As no more complex procedure than one for land ownership is required, they are relatively easier to get. In Kenya, it is thought large farm animals such as cattle belong to men while poultry belongs to women. However, a survey conducted by the International Livestock Research Institute (ILRI) and the International Development Research Centre (IDRC) revealed[7] that women had even less poultry than men. According to this survey

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5 African Development Bank (AfDB) 2007, *Country Gender Profile*

6 Federation of Women Lawyers, Kenya (Fida) 2013, Women's Land and Property Rights in Kenya

7 International Livestock Research Institute (ILRI) and the International Development Research Centre (IDRC) 2013, Women, "Gender and Ownership of Livestock Assets" by Jemimah Njuki and

targeting 232 households, the numbers of all kinds of farm animals owned by women are lower than those of men. Women own only one-tenth of cattle and approx. one-third of chickens owned by men. In addition, it is reported that many women think they cannot make decision about selling farm animals owned without their husbands' permission. Under 10% of women answered they could sell cattle without consulting their husbands while over 10% answered their husbands could sell their cattle without consulting with them. As to chicken for which women has a relatively strong decision-making right, 35% of women answered they could sell cattle without consulting their husbands while over 40% answered they needed to consult with their husbands for that.

It is often thought important cash crops belong to men. A postharvest sale is managed and used by men. Women gain an income by selling vegetables, poultry, or milk. The larger the income is, the more possibly men start to managing it. Some women prevent men from poaching their sales by reducing the amount to be sold at one time[8].

Not only ownership and control of lands, farm animals and harvests, but also access to things and information are limited. According to the African Development Bank (AfDB), though 80% of women assume agricultural work while approx. 7% benefit from agriculture extension services. According to The National Agriculture and Livestock Extension Programme (NALEP), there is no data about the male-to-female ratio of extension staff, but almost all of the staff is men. According to a survey conducted by Kiambu and Kajiado, 87.3% are men.

As access to financing is limited, access to seeds and fertilizers is also limited. According to a survey conducted by the United Nation Economic Committee for Africa (UNECA), the African Development Bank and the World Bank[9], agricultural productivity per hectare of men is higher by 8% that that of women. If the same human capital were invested to women as that to men and the same input were used to women as that of men, an increase of 20% could be expected in women's productivity.

In order to think about future agricultural mechanization from these issues, sufficient consideration is required so that women can benefit equivalently and they will not be negatively influenced. It contains promoting access to information and participation in training opportunities for mechanization, securement of access to credits necessary for purchasing machines or using agricultural machine service. In addition, any device to alleviate a negative impact by introducing agricultural machines is also required. For example, if crop acreage is increased when tractors and power tillers are introduced, only women are burdened with planting and weeding, which makes them overloaded. Consideration is required so that women are not negatively influenced such as understanding what work men and women do, reviewing division of labor based on gender and introducing machines that can reduce

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Samuel Mburu in *Women, Livestock Ownership and Market*, edited by Jemimah Njuki and Pascal C. Sanginga,

8 Anita Spring 2000, "Agricultural Commercialization and Women Farmers in Kenya" by Anita Spring in *Women Farmers and Commercial Ventures: Increasing Food Security in Developing Countries* edited by Anita Spring

9 Economic Commission for Africa 2014, *The Missing Link in Growth and Sustainable Development: Closing the Gender Gap*

labor of women. Considering work opportunities of young women and men who assume agricultural work decrease, regional employment creation and equality of new employment opportunities must be considered.

A survey conducted by KIT in 2015 caught actual division of labor based on gender in households in Bungoma in the west and Laikipia located in the central part and women's needs and verified what mechanization led to reduction of women's labor[10]. As the survey revealed almost all of work other than ploughing including postharvest processing was assumed by women, they recommend to focus on technologies and approaches for planting, weeding and postharvest processing in order to progress mechanization that meets women's needs. In the case of introducing power tillers rather than tractors, using attachments that reduce women's labor can reduce labor of ploughing and other work, especially postharvest processing. In addition, they also propose employing strategies such as directly working on female farmers and cooperating with households active in reviewing a gender relationship when running projects of introducing agricultural machines.

Vision2030[11], announced by the government of Kenya in 2006, aims at progressing conversion from a low-income country to middle-income country and social development, and indicates efforts about gender as important elements in social development strategies. Not only the Ministry of Public Service, Youth and Gender Affairs[12] are working on gender issues buy also other ministries and agencies are working on businesses under the policy with a perspective of gender adopted in each field.

The agricultural policy in Vision2030 is summarized as the Agricultural Sector Development Strategy 2010–2020 (ASDS), which points to human resource and social development as important factors for higher performance and preaches about the importance of women's contribution to agriculture. It says a perspective of gender should be adopted in all fields and levels of agricultural development as gender issues are cross-sectoral.

Table II.2.4 shows projects on gender issues, led by the Ministry of Agriculture, Livestock and Fisheries (MoALF[13]). Projects that specify that gender equity or female farmers are targeted as their goals are summarized.

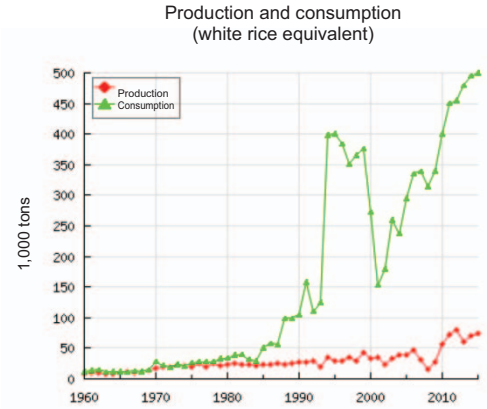
[10] KIT 2015, *Gender Matters in Farm Power*
[11] Government of the Republic of Kenya 2008, *Vision 2030*
[12] The former Ministry of Gender, Children and Social Development
[13] The former Ministry of Agriculture

Table II.2.4 Projects on gender issues[14]

Project name: Urban and Periurban Agriculture Project (UPAP) Conducted by: Government of Kenya Project Objectives: Creating more employment opportunities for young people and women and increasing their income through urban agriculture, stockbreeding and fishery
Project name: Agricultural Sector Development Support Programme (ASDSP) Conducted by: Government of Kenya and Swedish International Development Cooperation Agency (SIDA) Project Objectives: Increasing income of target groups of men and women and improving employment and food security through improving productivity and production efficiency of income from agriculture and other businesses of small-scale farmers in rural areas
Project name: Project for Enhancing Gender Responsive Extension Services (PEGRES) Conducted by: Government of Kenya and Japan International Cooperation Agency (JICA) Project Objectives: Improving extension service implementation abilities from a perspective of gender for small-scale farmers

3. Rice farming in Kenya

1) Environment surrounding rice farming



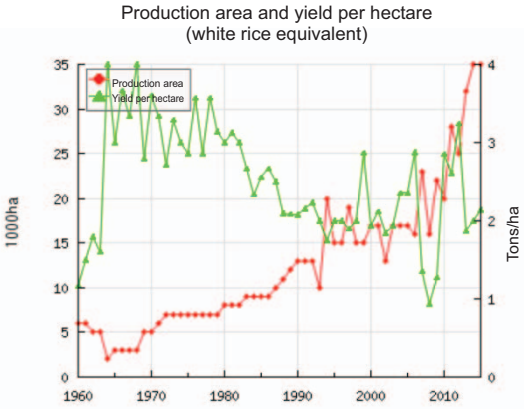


Figure II.3.1 Production and consumption Figure II.3.2 Production area and yield per hectare

Source: Shoichi Ito, PhD, World Rice Statistics and Graphics: Kenya (http://worldfood.apionet.or.jp/graph/graph.cgi?byear=1960&eyear=2015&country=KENYA&article=rice&pop=0&type=e1)

14 Central Planning and Project Monitoring Unit, Ministry of Agriculture, Livestock and Fisheries 2015, *Economic Review of Agriculture(ERA)*

Although the rice production has steadily been growing (Figures II.3.1 and Figure II.3.2), the consumption has risen much more rapidly, forcing Kenya to import more than 400,000 tons of rice from other countries. The per-capita consumption also increased significantly from 3.4 kg in 1980 to 55.5 kg in 2014, with the amount of consumption greatly rising mainly in urban areas. For farmers, rice is now one of cash crops. The increase in rice production is largely attributed to the expansion of farmland, with the yield per hectare being around 2 tons. The per-hectare yield has recently on the slight decline, as more farmers have come to use rainwater to grow rice and rice blast disease struck Mwea, one of the biggest rice-producing areas of Kenya.

2) NRDS

In response to the Kenya Vision 2030 and the ASDS, the Ministry of Agriculture, Livestock and Fisheries in 2008 worked out the National Rice Development Strategy (NRDS) and defined the following seven categories as priorities:

① Expansion of area under rain-fed and irrigated rice: The rice production in Kenya will be raised to 178,000 tons by 2018 from 73,000 tons in 2008.
② Reduction in field and storage losses of rice.
③ Improved farmer's access to credit and to high quality inputs
④ Improved farmers' access to certified rice seed
⑤ Provision of advisory extension support services
⑥ Provision of effective monitoring and evaluation (M&E) system
⑦ Strengthened human resource development

3) Current situation and problems surrounding rice cultivation in Mwea

The project of irrigation and settlement in Mwea scheme was developed by the British colonial government in 1953 as part of efforts to contain the independence movement led by the Mau Mau group. The irrigation area was as large as 5,860 hectares, and the production was 27,000 tons which was 66 percent of all the 41,000 tons of rice grown in Kenya at the time – were produced there in the late 1980s. But more than 30 years after the construction of the facilities, various problems have arisen, such as the aging of facilities, the lack of irrigation water and the resultant decline in productivity. Against such a backdrop, the Kenyan government requested Japan to offer financial and technical assistance. Based on the request, Japan has provided a series of financial and technical support in the form of official development assistance (ODA).

Kenya's organization in charge is the NIB, and the technical assistance is provided through the Mwea Irrigation Agricultural Development Centre (MIAD), an NIB subordinate organization.

Farmers' associations

Mwea Rice Growers Multipurpose Cooperative Society Ltd. (MRGM)

Mwea Rice Farmers Saving and Credit Cooperative Society Ltd. (SACCO)

Water Users Association (WUA)

(1) Development survey

Nippon Koei Co. conducted a development survey from July 1986 to January 1998. Project plans were developed for restoring and renovating the existing 6,000-hectare irrigation districts and developing new 4,000-hectare irrigation districts.

(2) Grant aid

1.264 billion yen in June 1989

896 million yen in June 1990

Exchange of notes to provide 597 million yen in July 1991

Using those funds, the Nyamindi headworks has been constructed, the Thiba headworks has been improved, major waterways have been renovated, training facilities have been built and agricultural machines and tools have been provided.

(3) Technical assistance

<1>～ From February 1991 through January 1998 ～

With the aim of establishing a proper irrigation-based technical rice farming system in Mwea, technologies related to irrigation water management, variety selection, soil improvement, verification of farming systems and other topics were provided to local people.

As the result of such support, the rice cultivation area grew to 9,200 hectares and the number of farming households increased to 4,600 in 2007, while the rice farming land totaled just 5,800 hectares and the number of farm households was 3,200 in 1990. After that, Mwea established itself as the most important rice-producing area in Kenya.

<2>～ January 2012 through January 2017 ～

JICA Project, The Rice-based and Market-oriented Agriculture Promotion Project (RiceMAPP) is currently under way.

With the aim of establishing sustainable rice production by enabling rice producers to establish a crop growing system that combines paddy with secondary crops and to improve their incomes from agriculture with the use of irrigation facilities in the Mwea irrigation area, technical assistance is being offered through MoALF.

(4) Yen loan

In August 2010, JICA agreed with the Kenyan government that it would extend up to 13.178 billion yen in loans to the Mwea Irrigation Scheme. It is a general untied loan. The loan is deferred for 10 years and is to be repaid in 30 years. The interest is 1.20 percent. The project is scheduled for completion in November 2016. The program is intended to expand the rice farming area from the current 7,860 hectares to 16,920 hectares by building dams and other means. It also aims to promote a two-crop system that combines rice with horticultural crops so that Kenya can improve its food security and the livelihood of farmers.

(5) Irrigated paddy and mechanization in Mwea

While the size of rice paddies in Mwea per parcel is small, large 80 or so House power tractors are typically used for cultivation and land preparation there currently. The other operations are conducted by humans. Local people apparently adopt the procedures largely because the soil is vertisol, which is common in tropical and subtropical regions. Vertisols are called the “black cotton soil” in local areas. That is because the vertisol is water-retentive during the dry season and superior in terms of chemical composition, making that type of soil suited to cotton cultivation. The vertisol is also suited to irrigated paddy cultivation, and it can be said that the feature, along with the development of irrigation facilities, has made Mwea one of Kenya's leading rice-producing areas. However, that type of soil becomes extremely hard in the dry season and becomes sticky in the rainy season – a characteristic unique to heavy clay. That means the vertisol is extremely difficult to handle in terms of physical features. Because of that, the cultivation process cannot be carried out with humans, cattle or power tiller machines, and farmers have no choice but to rely on powerful tractors.

(6) Situation surrounding rice farming in Mwea

According to the results of the Baseline Survey in May 2012, a farming family there has six members, owns 2.8 acres of land and yields 4.6 kg of paddy per hectare on average. While 99 % of farmers grow the Basmati rice, transplantation is conducted in the form of random planting (98 %).

The ploughing and land preparation work is carried out with large tractors (60 to 80 HP ones equipped with rotavators) in 93 % of all the cultivation areas. Of those lands, 72% is ploughed by individuals who own tractors for hire service, while the remaining area (25%) is ploughed by the MRGM or others for hire service.

90% of farmers conduct ploughing and leveling before transplantation with animals power (rakes drawn by two to four animals), and man power subsequently mix weeds and rice stubble into the soil with feet.

While 71% of farmers grow a single cropping with the ratoon cultivation, 13% raise a single cropping only and 9 percent engage in double cropping. Farmers sell 98% of their produced paddy, with 82% of the paddy for sale being sold through brokers (mostly front of farmer's house) or at nearby markets. The average paddy price is 48 Ksh (price ranging from 30 to 100 Ksh, depend on season).

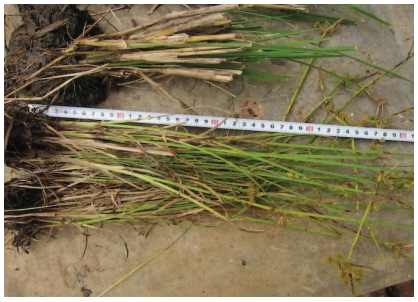
In Mwea farming operations have come to be conducted by specialized agents. In such a situation, agents using tractors that specialize in ploughing, paddling, leveling, transplantation, weeding and other operations have emerged (Table II.3.1). Thus farmers can now negotiate with such agents over all those farming processes by phone.

Table II.3.1 Major farm work and fee for each operation

Farm work	Machine to be used	Fee	Remarks
Tillage, soil preparation	Large tractors (60 to 80 ps) 2 to 2.5-meter-wide rotavator	3,500 Ksh/acre (11,000 yen/ha)	Time consumed: 40 to 50 minutes per acre
Leveling, ploughing before transplantation	Draft animals (rake drawn by four animals)	700 Ksh/acre	60 minutes needed
Weeding, leveling	Two labors	600 Ksh/acre	
Rice planting	10 labors	3,000 to 3,500 Ksh/acre	
Weeding, pest control	Labors work Herbicide:	600 to 1,000 Ksh/acre	Two agents spray herbicide from sprayer carried on the back.
Harvesting	Labors work Combine harvester:		

<1> Situation surrounding rice paddies and farm operations

Ploughing and land preparation take place in July and August. Rice stubble (ratoons) and Cyperaceous weed grow thick in the fields. In some fields, ratoons are raised. Such ratoons measure around 80 cm tall. Ratoons grown at the MIAD are intended to prevent damage to fields in other regions caused by birds by attracting them to its ratoon fields.



PhotoII.3.1 Cyperaceous weed

Counterpart (C/P) of the RiceMAPP said those weeds pose no problem for ploughing (an 80 HP, 4 wheel-tractor with rotavator to be used). Cyperaceous weed surveyed at fields of the MIAD measured 80 cm tall, while the rice stubble (in hand harvesting zones) was 25 to 30 cm high.

PhotoII.3.2 Rice stubble

<2> Irrigation

While farmers normally irrigate their fields two to three weeks before tillage, RiceMAPP C/P said four to five days are enough. According to C/P, if irrigating the fields earlier, the tractor could get stuck in the paddy field. Rice cultivation experts say irrigating the fields two or three days before tillage would also be fine. Irrigated paddies so early is apparently not beneficial, although there are slight differences in the outcome depending on the condition of the fields. When asked why they believe paddy field should be irrigated two to three weeks before, few farmers could clearly answer. Farmers reportedly irrigate fields so early, because they scramble to carry water from upstream farms to their own rice paddy fields as well as they want to grow the ratoon crop.

<3> Tillage

Farmers ordinarily plough the land with large tractors with rotavators. Rotavators just till the surface of soil at high speed, so the tractors rarely sink and get stuck. Leveling of paddy fields is insufficient, with the difference of elevation being 15 cm or larger. Where the soft soil near paddy sluices and elsewhere wheel track is typically deeply, so such areas need to be leveled by humans. Power tillers are not common in Kenya.


PhotoII.3.3 and Photo II.3.4

Ploughing by 4 wheel tractor

PhotoII.3.5 Power Tiller with

Moldboad plough on MIAD field

PhotoII.3.6 Power Tiller with

rotabator on MIAD field

<4> Paddling and Leveling

Tooth harrows drawn by two animals, which can also be used as levelers, as well as devices drawn by four animals (that have a 3.5-meter-long, 5-cm-thick leveler and steel rods arranged in a comb-like row), are frequently used.

PhotoII.3.7 Tooth harrows

PhotoII.3.8 Paddling by two ox

<5> Seedling cultivation

Seeds are traditionally sowed thickly in the seedbeds measuring 5 m by 5 m or larger. As a natural result of this, the seedlings are weak and undergo unproductive growth. The culm of the Basmati rice plant is especially thin. The MIAD and the RiceMAPP encourage the use of seedbeds separated by ditches.

PhotoII.3.9 Seedbed

PhotoII.3.10 Awns of Basmati

PhotoII.3.11 Traditional seedbed

<6> Weeding

An increasing number of farmers have come to use herbicides, because it requires a great deal of labor to remove weeds by hand (280 to 300 Ksh per half day). The Roundup herbicide is sprayed (1,350 liters × 2 per acre) before using the rotavator. Weeding is not done after that. If removing weeds by hand, the initial weeding alone requires 3,500 Ksh. When the weeding is conducted three times, the expenses would total 7,000 Ksh. When using the push weeder, three days per acre and 1,000 Ksh are needed.

The Saconil herbicide costs as much as 1,700 Ksh/L. Much millet can be found but it is not removed. Spraying of herbicides is conducted by agents specializing in herbicide spraying. The service costs 600 to 1,000 Ksh per acre. More types of operations, such as tillage, rice planting and weeding, have come to be carried out by dedicated agents in Kenya. The agents in the photo II.3.12 were

working with bare feet, without wearing boots, even though they were spraying Weedal (an India-made herbicide) in the field.

PhotoII.3.12 Spraying on barefoot

PhotoII.3.13 Measuring without globes

<7> Cleaning of fields

By using a large 4 wheel tractor, weeds can be raised easy by the rotavator without problems. The weeds are later stamped by humans and the weeds are never taken out of the fields. When using a power tiller in rice paddies, the weeds, straw and rice stubble (20 cm or taller) need to be cut down with a slasher (see the photo below) and brought out of the fields.

PhotoII.3.14 Removing residue

PhotoII.3.15 Slasher

<8> Traditional agricultural techniques

PhotoII.3.16,17,18　Ox trailer → waste → manure

Most farmers use manure (waste from barns). The left photo shows the waste from a pigsty, while the right photo shows one from a cowshed.

<9> Rice paddies after combine harvesters are introduced

The rice stubble height is 30 to 40 cm. Although the remaining plants are treated by pasturing

PhotoII.3.19　After Burning

PhotoII.3.20　Rice stubble

livestock or burning them, rice stubble still exists in the fields.

<10> Threshing

Harvesting is conducted under a double cropping system.　In a typical method, stones are placed on tarpaulin and the ear of rice is beaten against them, resulting in a larger loss of rice. Because of its superior shattering habit, the Basmati rice can easily be threshed.

<11> Straw treatment and livestock feed

Dried rice straw and green fodder are bundled using hay balers. The prices of the rice straw and dried grass are 250 Ksh and 300 Ksh per bundle, respectively. Those materials are popular as livestock feed, and creating such fodder has become a promising side job for rice farmers.

PhotoII.3.21,22,23 Rice straw and green fodder after processed by hay baler

4. Agricultural mechanization

1) Agricultural mechanization policies

Although the "Agricultural Sector Development Strategy 2009-2020" barely mentions the Kenyan government's mechanization policies, the "Ministry of Agriculture, Livestock and Fisheries Achievements" indicates that the current state of mechanization has man power accounting for 50% of work, animal power accounting for 20%, and motor-powered machineries accounting for 30%. Current administration party of Kenya (Jubilee Government) is pressing forward to increase agricultural production using modern technology, and it is considering using not only presently cultivated fields but also 2.5 million acres of as-yet unused land, as well.

The government is focusing particularly on mechanization at small- to mid-sized farms, aiming to transform subsistence farms into modern commercial farms and to expand production through mechanization. It is in this context that the government has formed a partnership with the government of Brazil to achieve mechanization for farmers at reasonable prices. Additionally, with Japanese grant aid, MoALF has begun supplying ¥460 million worth of farming machinery to rice farmers. Initial procurements are 15 of 80 HP tractors, 5 of 30 HP tractors, 15 combine harvesters, reapers, and thresher.

2) Current state of mechanization

The KENDAT (Kenya Network for Dissemination of Agricultural Technologies) and CIMMYT (International Maize and Wheat Improvement Center) report "Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) Project Market Analysis for Small Mechanization-Kenya" (J. Mutua et al.) describes in detail the current state of mechanization in Kenya.

This report discovers that, due to the increasingly narrow division of farming land into smaller pieces through land fragmentation, there is potential from an economic perspective for the use of smaller machineries like power tillers rather than 4 wheeled tractors. Moreover, the report states that implements, trailer, and other elements of a power tiller can be swapped out for different tasks like sowing, threshing, and transport to improve utilization, thereby efficiently increasing agricultural production.

The report also attaches great importance to the use of motorbikes for transport and shipping in agricultural villages in recent years, and discusses how this might lead directly to a service sector for the maintenance of agricultural machinery.

In terms of government services for agricultural equipment, MoALF had 23 agricultural machinery service (AMS) stations set up throughout the country. Each station owned earth-moving machineries and tractors, and profit-earning public machineries hire services were offered. Service fees were maintained below market rates at 1,500-2,000 Ksh per acre. However, with the shift toward county administrative independence, it seems that problems have arisen with the range and provision of services. Yet even with AMS, the usefulness of power tiller is appreciated due to the reduction in field sizes in terms of area.

3) Issues in agricultural mechanization

According to the "National Agricultural Mechanization Strategy: MAMS" (1995) and "Strategy for Revitalizing Agriculture (2004-2014): SRA," there are three reasons that mechanization has not progressed in Kenya: 1) Insufficient mechanization-spreading services; 2) Insufficient access to mechanization technology; and 3) Insufficient financial services usable by farmers. To address these issues, the papers state that policies are required which provide necessary incentives in each sector.

Prices are also taken as an issue. Although the Kenyan government had exempted agricultural machineries from the value-added tax (VAT) since 2003, the government reintroduced a 16% VAT in September 2013. At the same time, the government also imposed tariffs on the raw materials needed by agricultural machinery manufacturers, leading to even higher prices. As a result, the agricultural machineries and implement manufacturers of Ndume Ltd. and others became less capable of competing.

4) Manufacturers and sellers of agricultural mechanization

The reports of J. Mutua et al. have contained lists of agricultural machinery manufacturers and sellers. Local manufacturers are Ndume Ltd., Jalbert Engineering, and Kickstart.

(A) Ndume: One of the most important company. Produces a wide range of agricultural machinery based on received orders.

(B) Jalbert: Officially registered as the self-help organization Jua Kali, this organization provides training in maintenance and other topics for local young people. It is also facing financial problems.

(C) Kickstart: Officially, this is the NPO known as ApproTEC. Develops low-cost agricultural technology, which it sells throughout Africa. One of its most famous products is MoneyMaker, a treadle irrigation pump.

In the city of Nakuru there is the Ministry of Agriculture's Agricultural Technology Development Center (RTDC), which provides useful work implements to small farms.

Sellers, including sales agents, exist for both public and private services separately. These include KFA (public), FMD, Rift Valley Machinery, Holman Brothers, and Hekima Engineering Works. Public services have been shrinking in recent years. The KFA imports agricultural machinery through the Ministry of Cooperative Development, but its service offerings have been shrinking due to financial problems.

Other agricultural machinery sellers are as follows:

(D) Toyota Tsusho Corporation (East Africa): Primarily an automobile seller, but also a sales agent for Yanmar Co. However, they do not showcase their products for display, and power tiller and tractors are both at the market research stage. In reality, all agricultural machinery they handle is left to CASE, and in terms of products it handles mid-sized to large machinery of 50 HP or more. The relevant responsible personnel at the company has voiced the opinion that, with the reduction in field size due to inheritance, the market for 30 HP riding tractors will increase in the future. Demand for Yanmar products faces problems with price competitiveness, as for example the CASE 80 HP product is the same price as the Yanmar 40 HP product.

(E) Car and General: Its HQ is in Nairobi, with sister companies in Uganda, Tanzania, and other locations. Kenyan branches are located in cities like Nakuru, Mombasa, and Kisumu. Sells its small power tiller as weeder “Garunda” (5 HP) for 150,000 Ksh. Imports Kubota 4 wheel tractors and has them in stock. As per company strategy, 30% of tractors sold are small tractors and 60% mid-sized or large. Also sells motorcycles and similar, actively stocking up and providing maintenance. In terms of agricultural machinery, although they display 20-90 HP Kubota tractors, it seems that medium- to large-scale mechanization is the core of the strategy.

(F) Brazafriq: Brazilian company. Imports and sells planters, seed sorting machines, subsoilers, disc plough, etc.

(G) CAMCO Ltd: Chinese agricultural machinery company.

(H) Nonman Tractor and Farm Equipments: Imports tractors from the UK and Japan. Its brands are Massey Ferguson and Cherry.

(I) Massey Farguson (Farm Mechanization Division: FMD): Sells riding tractors and implements. Does not sell power tillers.

(J) John Deer

(K) Sametrack

(L) Holman Brothers

(M) Nyabon Enterprises Ltd.

5) Distribution of agricultural mechanization

According to the reports of J. Mutua et al., distribution is essentially similar for riding tractors and power tillers. Importers and seller agents sell to large farms and, in some situations, small farms. For the most part, large farms provide hire services to small farms. Small farms rarely buy riding tractors, and if a small farmer acquires a power tiller, it is generally believed that an NGO or government subsidy was responsible.

5. Trial and Survey of Mechanization in Kenya

1) Trial of preparation of paddy field

(1) background

In this project, in order to find possibility of mechanization for small-scale rice farmers, the project targeted Mwea irrigation scheme. As mentioned previously, it has already been introduced big tractor and this has become the mainstream of preparation activity in Mwea currently.

On the other hand, in the outer area of scheme, it would be difficult for a big tractor to enter because narrow road and field that is easy to sink down. Therefore, in this study, we set three situation to see productivity and cost of land preparation. It means (1) manpower, (2) power tiller and (3) big tractor.

(2) Result of trial

Result is showed on table II.5.1.

Table II.5.1 Comparison of activities time and cost

Plot	Activities	Time (hours)	Labor cost (Ksh)	fuel (Ksh)	Total cost for farmers (Ksh)
Manpower	ploughing(1st)	80.0	8,000	–	8,000
	ploughing(2nd)	31.3	6,000	–	6,000
	Leveling etc.※	56.7	2,700	–	2,700
	subtotal	*168.0*	*16,700*	*0*	*16,700*
Power tiller	ploughing	4.4	1,000	317	1,317
	Leveling by Oxen※	1.0	700	–	700
	Leveling etc.※	56.7	2,700	–	2,700
	subtotal	*62.1*	*4,400*	*317*	*4,717*
Big tractor	ploughing	0.9	4,500	–	4,500
	Leveling by Oxen※	1.0	700	–	700
	Leveling etc.※	56.7	2,700	–	2,700
	subtotal	*58.6*	*7,900*	*0*	*7,900*

※：Results were shared because of seme activity

2) Trial of harvesting and threshing of paddy

Trial items were two items as follows.

(1) The test was carried out using combine harvester and manpower harvesting activity.

(2) It was carried out post-harvest treatment summary investigation in Mwea irrigation scheme.

Result of manpower activity is showed following table II.5.2 and table II.5.3

Table II.5.2 Harvesting by manpower

Starting time	Finishing time	Activity time	Activity time per person and acre
07:30	11:00	3:30	28:00
07:00	11:00	4:00	32:00
06:30	09:00	2:30	22.5
Average			27.50

Table II.5.3 Threshing by manpower

Starting time	Finishing time	Activity time	Activity time per person and acre
11:00	13:30	2:30	20:00
11:00	13:30	2:00	20:00
09:30	11:00	1:30	13:50
Average			18:00

In the case of combine harvester, 6000Ksh / acre ~ 7000Ksh / acre in the busy season (including fuel costs and operator cost) (7,300 to 8,500 yen). The average area which harvested by combine harvester was 10-12 acres, and average time was about 40 to 45 minutes / acre, fuel consumption was 8-10 liters / acre. As a result, when comparing the time and cost of manpower and machinery, the contents of the table II.5.4. In the results, harvesting and threshing activity time was about 61 times faster than manpower and activity cost resulted from 1.2 to the same.

Table II.5.4 Harvesting and threshing time and cost

	harvesting (hours)	threshing (hours)	cost (Ksh)
Manpower	27.5	18.0	7,000
Combine harvester	0.75 (45 minutes)		6,000～7,000

3) Post-harvest treatment of investigation

About rice mill including big and small scale, there might be more than 140 mills in Mwea irrigation scheme. In this project, with the cooperation of RiceMAPP experts, we choose three type of mills, (1) large-scale plant in Wang'uru town, (2) small-scale mills in Wang'uru, (3) small-scale mills in a suburb area of Mwea irrigation scheme. Place of the mill are shown in Figure II.5.1.

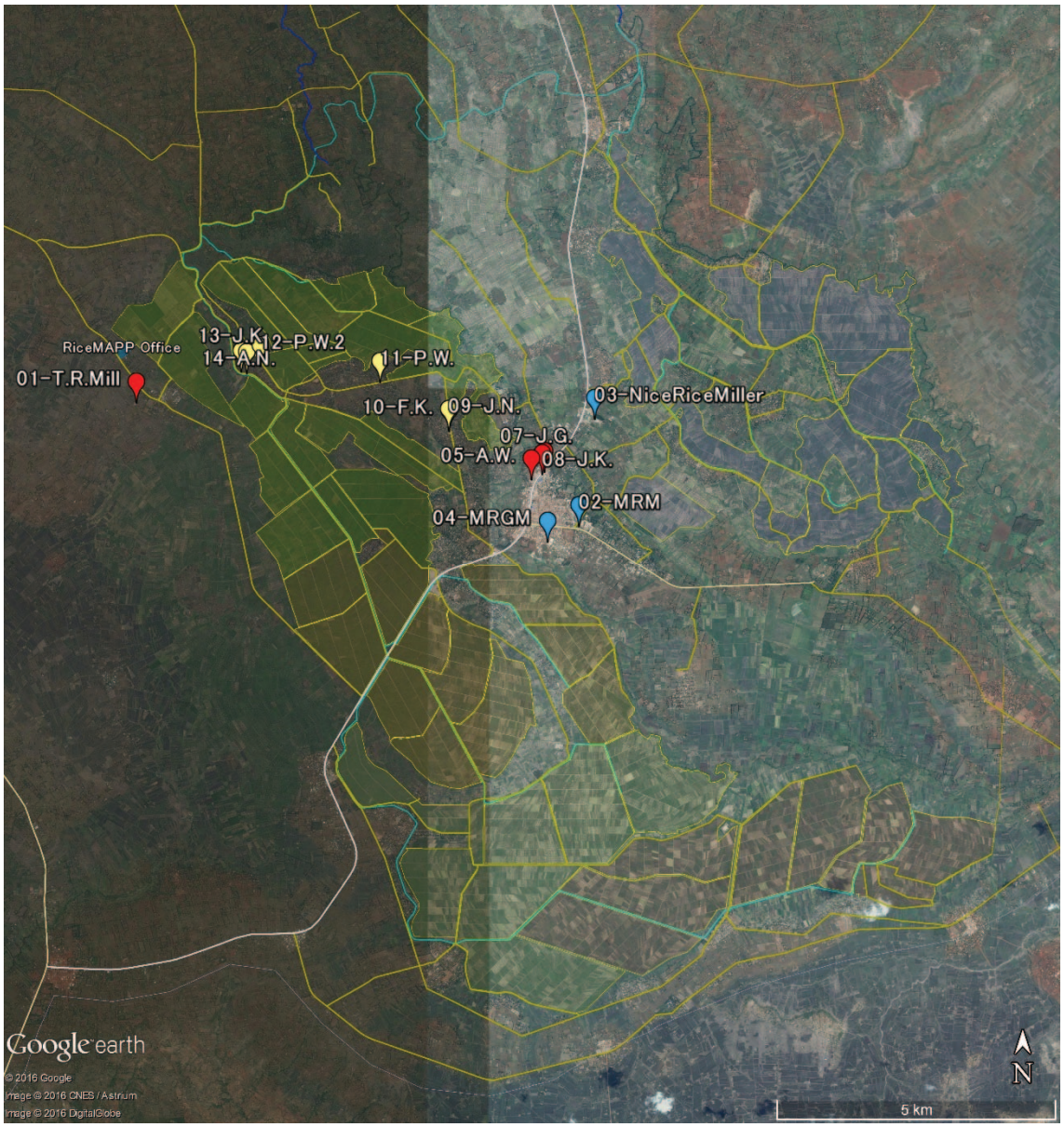


Figure II.5.1 Rice mill which we interviewed in the survey
(blue : (1) large-scale plant in Wang' uru town, red:(2) small-scale mills in Wang' uru, who uses Mill-top type, yellow:(3) small-scale mills who uses only improved engelberg type)

4) Result of rice mill survey

Result is showed on table II.5.5. In this table includes results of survey which conducted in Nairobi supermarket.

place	target mills	type of mills	paddy moisture	ratio of broken rice	No. of stone (500g)	No. of husk (500g中)	whiteness	Grade	selling price (1Ksh/kg)	
1	Mwea(small-scale)	Mill-top type	10.3 %	18.0 %	51.2	1.7	44.2	-	117.5	※1
2	Mwea(MRM.Ltd.)	Big plant	11.7 %	24.0 %	0.9	3.5	43.5	-	112.5	※1
3	Mwea(NiceRiceMiller)	Big plant	11.8 %	14.0 %	0.0	0.0	43.2	Grade1	150	※2
4	Mwea(MRGM)	Big plant	10.3 %	10.0 %	0.0	2.0	39.7	-	122.5	※1
5	Mwea(small-scale)	Mill-top and Engelberg	9.9 %	46.0 %	4.4	38.1	40.7	-	117.5	※1
-	Mwea(small-scale), fail to collect data	-	-	-	-	-	-	-	-	
7	Mwea(small-scale)	Mill-top type	10.1 %	22.0 %	11.6	3.6	45.2	-	115.0	※1
8	Mwea(small-scale)	Mill-top type	9.5 %	30.0 %	1.8	0.9	43.0	-	107.5	※1
9	Mwea(small-scale)	Improved Engelberg	10.6 %	16.0 %	0.0	1.0	40.3	-	115.0	※1
10	Mwea(small-scale)	Improved Engelberg	12.6 %	30.0 %	8.8	0.0	45.7	-	110.0	※1
11	Mwea(small-scale)	Improved Engelberg	12.4 %	42.0 %	2.6	0.0	46.2	-	115.0	※1
12	Mwea(small-scale)	Improved Engelberg	11.3 %	64.0 %	19.7	2.9	47.9	-	85.0	※1
13	Mwea(small-scale)	Improved Engelberg	11.4 %	44.0 %	9.4	4.7	43.0	-	110.0	※1
14	Mwea(small-scale)	Improved Engelberg	11.4 %	16.0 %	16.4	1.9	39.5	-	110.0	※1
-	Nairobi(Nakumatto Blue Label)	-		26.0 %	0.0	0.0	42.3	-	160	※2
-	Nairobi(Pearl Kenya Pishori)	-		4.0 %	0.0	0.0	41.5	Grade1	198	※2
-	Nairobi(S&S Pure Mwea Pishori)	-		26.0 %	0.0	0.0	40.6	Grade1	180	※2
-	Nairobi(CIL Pure Mwea Pishori)	-		16.0 %	0.0	0.0	44.7	Grade1	185	※2
-	Nairobi(NRC Mwea Rice Pishori)	-		4.0 %	0.9	0.0	41.5	-	165	※2
-	Nairobi(Nafaka Foods Pishori)	-		24.0 %	0.0	0.0	39.2	-	178	※2
-	Nairobi(Winnie's Pure Health Brown Rice)	-		2.0 %	11.8	3.9	19.4	-	215	※2
-	Nairobi(India Gate Basimati Rice)	-		2.0 %	0.0	0.0	39.0	-	215	※2
-	Nairobi(DAAWAT Basmati Rice)	-		2.0 %	0.0	0.0	39.6	Grade1	202	※2
-	Japanese "Koshihikari"	-		2.0 %	0.0	0.0	41.5	-	-	

※1 : It is avarage of Max and min price because selling price was fluctuating.
※2 : It is retail price on Feb. 2016.

5) Comparison small and large machines and consideration of their advantages

In agricultural mechanization in Kenya, tractors were introduced mainly in estate agriculture before independence. However, as lands were individually owned with independence, segmentation due to growth of population, used variedly and fragmented like a mosaic for various crops, which HP reduced a situation in which agricultural machineries were difficult to use. As the situation in Kenya is typical, there are many farmers who manage self-sufficient agriculture by family labor, there farming area is limited and they rarely own machineries personally. Meanwhile, since independence, government-led tractor hire services have been used by farmers for a long time. However, in the 1990s, with structural adjustment by the World Bank, the services were privatized. In Mwea a system was introduced in which associations owned machineries and provided such services for members on behalf of the government. In addition, some tractor owners started the services as a new business model.

As seen above, as tractors have been accepted by the public for agricultural mechanization, about 80 HP tractors have been established among farmers as standard tractors for governmental tractor hire services. In ploughing process, because soil is hard and heavy clay named black cotton soil, farmers usually irrigate water to field and make flooding for about three days to make the soil which becomes dried and sprung during dry season. After that they start paddling and leveling by Ox and man power. Is it impossible that farmer purchases privately power tiller and replace big tractor?

In the previous section, we compared economic efficiency between man power and power tiller, we compare ploughing services offered by the MRGM and power tiller in this section. The hire service of ploughing charge is 4,000Ksh (approx. 4,800 yen) per acre. Assuming 6.4-hour work a day covers 1.5 acres, and the ploughing charge by power tiller contain the introduction cost of one power tiller of 500,000 yen and the durable life of four years (approx. 2,000 hours), the annual allowance for depreciation is 125,000 yen. Assuming the repair cost is accumulated to 50% of the purchase expense for the durable life, the variable cost a day by a power tiller (assuming one acre) is 2,804 yen (Repair cost 1,000 yen + Operator cost 1,000 yen + Fuel cost 804 yen). However, interests and variable cost are not considered. The ploughing charge for a tractor is 4,000Ksh (4,800 yen) per acre similarly. Assuming the cultivation charge by 80 HP tractor with rotavator is 4.8 million yen, the durable life is eight years (approx. 10,000 hours), the repair cost is accumulated to 50% of the purchase expense for the durable life and 8-hour work a day covers 8 acres, the annual allowance for depreciation is 600,000 yen. Assuming the repair cost is 1.920 yen for use of eight hours a day and the operator cost is 1,500 yen, the variable cost a day is 9,852 yen in total.

Calculating the break-even point based on these conditions, it is 62.6 days. As it is 27.1 days for tractors, tractors are more profitable. However, as it is predicted that the greater the movement distance to an agricultural field is, the larger the service area is, there is a great possibility that more actual work hours cannot be taken than using power tiller as the number of operation days becomes higher.

Initial investment capacities are extremely important for individual farmers to own agricultural machineries. As described previously, though commercial banks offer agricultural financing systems,

few rice growing farms use the systems except for some farmers that develop commercial business such as rice mill etc. From this standpoint, a barrier to introducing power tillers is low. Therefore, in order to lower the barrier to entering the ploughing service, measures to alleviate the problem of initial costs are important.

Harvesting is important in relationship with the quality of rice for considering rice growing. In addition to reducing immature rice grains by harvesting in proper time and ensuring the maximum amount of harvest, harvesting at an appropriate water content level reduces a burden in postharvest processes and broken and cracked rice. Because of this, introduction of agricultural machineries is greatly advantageous for a region like Mwea irrigation schemes stretching over rice-producing areas. So, we compare costs of reaping and husking by a reaper and combine harvester.

We refer to Japanese agricultural machineries introduced for free by an aid for poor farmers. The machineries are Yanmar YAP120 as a reaper, Yanmar DB1000 as a thresher and Kubota DC70 as a combine harvester. We assume work hours are two hours, four hours and one hour per acre, and prices are 480,000 yen, 38,000 yen and 5.2 million yen, respectively.

To calculate the break-even point per acre, we assume sales for reaping per acre is 2,400 yen and reaping of two acres is possible a day. Assuming the durable life is five years, the annual allowance for depreciation is 80,000 yen. Assuming the fuel cost is 960 yen, the repair cost is 384 yen, the operator cost is 1,000 yen and the travel cost is 920 yen, the variable cost is 3,264 yen. Interests and variable cost are not considered.

We assume two farmers, A and B. Farmer A anticipates 30 days for a normal cropping season and 15 days for ratoon; 45 days in total. Meanwhile, Farmer B anticipates 60 days for a normal cropping season, 30 days for a different crop season, and 30 days for ratoon; 120 days in total. Calculating the break-even point based on the assumption above, it is 62.5 days as shown in Figure II.5.1. Therefore, posting a loss, Farmer A cannot depreciate unless they operate for 17.5 days.

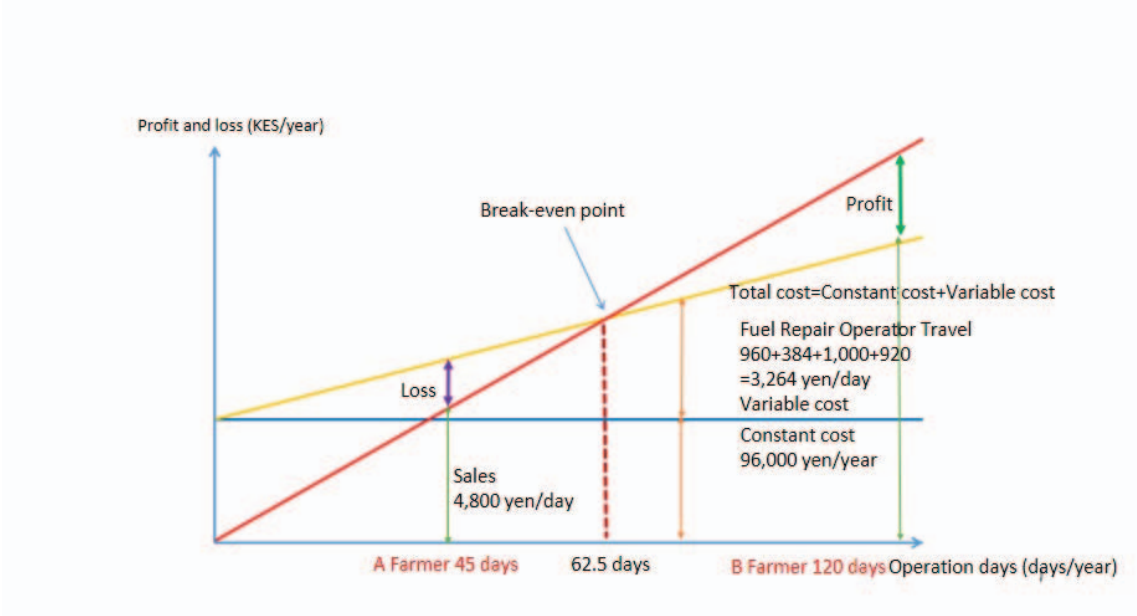


Figure II.5.1 Break-even point in the case of entrusting reaping

Then, we consider threshing work. Threshing of one acre requires four hours, but we assume workers other than operators from a farm complete the work in a single day. The sale per acre is 2,000 yen excluding the cost for workers of 1,200 yen. Assuming the durable life is five years, the annual allowance for depreciation is 72,000 yen. Assuming the fuel cost is 1,620 yen, the repair cost is 288 yen, the operator cost is 600 yen and the travel cost is 600 yen a day, the variable cost is 3,108 yen. In this case, the break-even point is 80.7 days. However, in the case any means of transportation can be obtained and the cost is 0 yen, the variable cost a day can be reduced to 2,508 yen and the break-even point can be reduced by approx. 40% to 48.2 days.

Then, we calculate it as to a combine harvester. As it can perform threshing simultaneously in a period of time with no morning dew, we assume harvesting requires four hours on four acres, work charge is 7,200 yen per acre a day. Assuming the durable life is eight years, the annual allowance for depreciation is 650,000 yen. Assuming the fuel cost is 4,860 yen, the repair cost is 2,600 yen, the operator cost for two operators is 2,000 yen and the travel cost is 3,000 yen a day, the variable cost is 12,460 yen in total. From the assumption, the break-even point is 39.8 days. As calculated here, it is clear that profitability is higher when a large machinery is used. Assuming agricultural labor costs become higher, a large machinery is more advantageous. However, only organizations such as large-scale agricultural associations that are self-funded or that can that can get financing from a bank can own their combine harvesters.

For the progress of mechanization by small machineries, it is appropriate that small-scale farms call upon hopeful people who want to use machinery hire services, invest in them and build a mechanism in which machineries are communally used based on specific rules as it is difficult for them to get financing from a bank.

As described above, large machineries assumed to be used only in rice-growing areas seem more advantageous, but power tiller have comparative superiority that they can turn on a dime in areas where there are no agricultural roads and approach paths for tractors in a segmentalized and mosaic field. Even in an irrigation scheme like Mwea, farmers generally grow corn as a staple food in fields near their houses. Considering such a situation, it is predicted that it is just a matter of time before laborers immigrate into the secondary or tertiary industries with the progress of economic growth and demands for small agricultural machines grow.

6) Improvement of availability ratio by multipurpose use and wide-area agricultural machinery service (conversion of work method)

As tractors have PTO (Power Takeoff), they are made on assumption that they use implements excepting traction-type. Meanwhile, as to the engine of a power tiller as a source of power, the V belt must be replaced or a pulley for the flat belt must be mounted to the flywheel to obtain power. In the 1995s when power tillers were popular in Japan, equipped with rubber wheels for easier run, towing a trailer, they were used for conveying not only thresher and power sprayers but also iron wheels and

cage wheels. In a rice field or blank space, threshing, husking were performed by connecting a flat belt using the engine of a power tiller as a source of power and irrigation was performed by connecting a pump to it. More and more farmers have been using motors as sources of power with electrification. In Sub-Saharan countries, the existence value of engines is significant as sources of power.

If mechanization based on power tillers is pursued, it is better to use power tillers' engines than engines dedicated for thresher. Only this keeps prices down by about 100,000 yen and highly possibly reduces maintenance and management costs. As to costs for reaping calculated as travel costs, in the case a farm can convey by itself with a power tiller equipped with a trailer, the outsourced travel cost can become 0 yen, which is helpful in cost reduction.

Reapers are available for harvesting wheat in addition to rice. However, as there is no production area for wheat nearby in Mwea and they are transferred 100km or farther, an issue is operation and management in a remote area. A reaper can be used for reaping pasture grass, but being generally dense, it places a burden on its feeding mechanism, highly possibly causing clogging and damage on the safety pin. To use a reaper, response on assumption of reaping by it is required row and sparse planting.

Thresher can be transferred by using the same screen even for wheat and adjusting the number of rotations. Though a coarse screen must be used for beans such as soy beans, it can be transferred to a sheller for beans etc.

Selection is conducted by women in the drying process. As part of postharvest processing, using a winnower after drying removes trash. This can reduce work hours of women and risk of striking a hard bargain by rice mills and pickup buyers for farmers.

As seen above, using power tiller with agricultural power and working machineries to multiple crops for multiple purposes can control the depreciation allowance per usage hour and reduces overall machinery costs.

Furthermore, using them in production areas with different areas reduces constant costs per hour, but it is expected to be difficult in terms of acquisition of customers in remote areas, and operation and management. The box below shows best practices of tractor hire services in Kenya.

Box Hire ploughing service model in Kenya

Mr. Gideon Gitungo Kingangi, leasing, tourism (operation of tour wagon)

Owned machine (Initial payment 30%, Payback period 2 years, Purchased from at a rate of interest per annum of 15%)

- CASE JX80 4WD (2009) 3.4 million Ksh
- Disk plough Triple 66cm 0.4 million Ksh
- Disk harrow 24 x 56cm 0.4 million Ksh

He purchased using a dealer's in-house financing. Accepting orders over wide areas ensures an annual work period of 10 months. Having a contract with an operator to pay 10% of the commissioned business fee as an allowance has a strong incentive.

7) Evaluation of rice quality and clustering of the rice industry

In order to verify to what extent the quality of rice was reflected on the price, we interviewed traders in August, 2015.

We prepared three types of rice of 100g with different rice cracking ratios and asked the market prices of these. These samples were (1) Rice sold at Grade 1 in a supermarket in Mwea, (2) rice with rice cracking ratio of 25% and (3) rice with rice cracking ratio of 50%. According to the standards of the Kenyan Standards Association, Grade 1 refers to the rice cracking ratio of 10% or less while (2) and (39 correspond to Grades 2 and 3, respectively. However, as introduction of a new standard requiring lower rice cracking ratios is expected, a higher quality is needed. Table II.5.1 shows the results of the survey.

Table II.5.1 Results of the survey of predicted retail prices associated with the rice quality (Unit: (Kenyan Shilling (Ksh))

No.	Granulating ratio (%)			Difference in price (95 - 75 %)	Difference in price (75 - 50 %)
	95%	75%	50%		
1	120	110	105	10	5
2	115	112	110	3	2
3	115	110	107	5	3
4	115	113	110	2	3
5	115	115	110	0	5
6	115	110	108	5	2
7	120	110	100	10	10
8	110	90	80	20	10
9	115	105	90	10	15
10	115	105	100	10	5
11	115	110	100	5	10
12	115	110	90	5	20
13	115	105	90	10	15
14	120	105	90	15	15
15	120	110	105	10	5
16	120	110	95	10	15
AVE	116.3	108.1	99.4	8.1	8.8
SD	2.9	5.7	9.2	5.0	5.8

A standard price of Grade 1 at the time of the interview was 115Ksh. As almost all traders gave that price, the average price was 116.3Ksh and the standard deviation was 2.9, which were very low. When the rice cracking ratio was 25%, the minimum price was 90 while the maximum price was 110, which showed a big difference. The average price is 108.1Ksh, which was different from that at Grade 1 by 8.1Ksh. When the rice cracking ratio was 50%, there was a difference of 30Ksh between the minimum and maximum prices. The standard deviation was 9.2Ksh. The average price of 99.4Ksh, which was different from that at Grade 2 by 8.8Ksh. From the results, seeing the rice cracking ratio of 25%, a decline stayed at 7%, which showed the quality slightly influenced the price. When a difference in price is small, as an incentive of aiming at improved quality does not work greatly, it is pointed out no movement according to any public standards occurs even if they are set. Actually, when interviewing rice mills, even large mills had no moisture meter for quality control by numerical values.

Furthermore, not a few mills combined perfect rice grains and broken rice grains even though there were four outlets of the rotary shifter. The greatest multipurpose cooperative association in Mwea had a rice milling facility with a color sorter, but they did not use it at the time of the interview.

Meanwhile, a rice miller that has developed its original value chain has appeared whose business model has been gaining attention. The manager succeeded in collecting customers by a hotel with a supermarket, restaurant and pool as a compound, centering on rice milling. It is a new business model that has introduce the catering and tourism industries as a backward linkage of rice milling. Rice milling had been operated by a public corporation in a monopoly in Mwea as positioned as a place of rice production. However, after the structural adjustment, it was privatized. There are approx. 120 small-scale rice mills and five middle- and large-scale mills. In Wang'uru, a center place of Mwea, there are more shops and companies that provide agricultural inputs such as fertilizers and agricultural chemicals and production-related services such as agricultural machine services as forward linkage, which can be called as a rice industry cluster.

The rice industry cluster contains rice production, and drying, rice milling, warehousing and selling as postharvest processing and involves the food and tourism industries. It is constituted by rice mills that connect the markets and producers. This is, rice mills play an important role as a pivot of the rice industry that connect the value chain of rice. It is required in a role of a strong driver by institutionalizing a rice mill association. There are not a few developing countries whose major business is agriculture. These countries aim at regional development by forming an industry cluster in areas that produce special local crops in a situation that they have to place agriculture as their major industry. Attention must be paid to the rice industry cluster as a case of a new rural development approach.

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2) Tokida.K, Haneishi.Y, Tsuboi.T, Asea.G, Kikuchi.M. (2014): Evolution and prospects of the rice mill industry in Uganda. African Journal of Agricultural Research, 9(33), 2560-2573.

Chapter 3 Summary of Three Years Activities

1. Uganda follow-up study

1) Farming management of Mr. Okullo Peter

(1) Second-hand power tiller purchases

The follow-up study in Uganda last Japanese fiscal year (2014) studied the farm management of northern Lira District rice farmer Peter Okullo, to whom 3WM Uganda leased a Japanese branded (Indonesia Yanmar) power tiller and implements.

This fiscal year, Mr. Okullo did not lease but rather bought second-hand the same machinery from 3WM. He paid 3 million Ush (¥102,000) in advance for the power tiller returned to and refurbished at 3WM after last year's lease ended, having the power tiller sent back to Lira District. However, due to slow payment by Mr. Okullo, delivery of the power tiller was delayed, and on April 18, 2015 (later than scheduled) he eventually received the machinery listed below.

- Power tiller (Indonesia Yanmar -made Bromo DX)
- Cage wheels (Chinese-made)
- Moldboard plough (plough only)
- Disc ploughs (two)
- Seeder (Chinese-made)
- Trailer (TONNET Ltd.-made)

(2) Use of the power tiller

Mr. Okullo expected that his farm work this Japanese fiscal year would consist of 1) rice farming on his own property, 2) rice farming on shared lands (discussed later), and 3) contract farming (hire service).

In reality, Mr. Okullo conducted both first ploughing and second ploughing of two of his properties, Ireda and Gwengabara, but then he abandoned farming on his own properties due to low rainfall. As a result, he focused his efforts on 2) rice farming on shared lands and 3) services.

On shared lands, this year Mr. Okullo farmed rice on land shared with Mr. Bosco Kabengo. On shared lands (approx. 10 acres, 4 hectares, in the Agali region) called "partnership fields" by Mr. Okullo, he and Mr. Boscoagreed to joint cultivation under the following conditions.

- Mr. Okullo would provide the seeds and machinery.
- Mr. Bosco would pay for the land rent as well as fuel costs and operator costs incurred during work.
- Cultivation would proceed based on Mr. Okullo's advice and direction.
- The two men would evenly split the post-harvest expenses and sales revenues.

In most cases, power tiller services were provided according to this process: 1) with the trailer mounted to the power tiller, all implements were placed on the trailer, and the power tiller was taken from its storage location to the work field. After arrival, 2) the trailer was removed in the field; and if ploughing, either the moldboard plough or the disc plough was attached; if sowing, the seeder was

attached and work was performed. For the work of preparing the rice field by flooding it and ploughing the soil, the rubber tires on the power tiller were swapped out for cage wheels.

2) Outcomes

<1> Work outline

Mr. Okullo was requested to maintain an activity log just as he had last year. For the 8-month period from May to the end of December 2015, the power tiller was used for 400 hours in approx. 70 acres of field (28 hectares).

Due to the delayed arrival of the power tiller and subsequent repairs, the power tiller only became useable in late April and only began to be used in May.

Table III.1.1 and Table III.1.2 contain aggregated final statistics for all power tiller use.

Table III.1.1. Aggregated final statistics for power tiller across all activities (time, location, area, revenue, expenses, fuel costs)

<table>
<tr><td rowspan="2">Days in operation</td><td rowspan="2">59 days (approx. 400 hours)</td><td>Work: 370 hours</td></tr>
<tr><td>Transport: 30 hours
(Distance travelled: 365 km)</td></tr>
<tr><td rowspan="4">Work sites</td><td rowspan="4">11 locations,
approx. 70 acres (28 hectare)</td><td>Ploughing: 60 acres
(approx. 24 hectares)</td></tr>
<tr><td>Sowing: 7 acres
(approx. 2.8 hectares)</td></tr>
<tr><td>Paddling: 2 acres
(approx. 0.8 hectares)</td></tr>
<tr><td>Transport: 24 km</td></tr>
<tr><td colspan="2">Collected hire serveice fees</td><td>2,780,000 Ush
(approx. ¥95,000)</td></tr>
<tr><td colspan="2">Work fees to operators (3 people)
(incl. private property, shared property, and hire service)</td><td>1,352,000 Ush
(approx. ¥46,000)</td></tr>
<tr><td colspan="2">Maintenance and repair costs</td><td>394,000 Ush
(Approx. ¥13,000)</td></tr>
<tr><td rowspan="2">Fuel use</td><td>For work (approx. 90L):
297,000 Ush</td><td rowspan="2">491,700 Ush
(approx. ¥17,000)</td></tr>
<tr><td>For transport (approx. 59L):
194,700 Ush</td></tr>
</table>

Table III.1.2. Power tiller use by Mr. Okullo personally (incl. shared land)

Date	Owner of Field	Location	Activities	Size (acres)	Transport fuel (L)	Acticity fuel (L)	Fuel cost (UGX)	Labor cost (UGX)
5/8-10	Family	Ireda	1st ploughing	2	1.8	1.3	10,230	40,000
5/10-18	Partnership field	Agali	1st ploughing	9.9	7.6	16.0	77,880	194,000
5/29-30	Okullo Peter	Gwengabara	1st ploughing	1.4	3.9	2.3	20,460	25,000
6/12-7/3	Partnership field	Agali	2nd ploughing	10.2	8.3	13.4	71,610	200,000
7/6	Okullo Peter	Gwengabara	2nd ploughing	1.4	1.5	1.7	10,560	25,000
7/7-14	Partnership field	Agali	3rd ploughing	10.8	8.1	13.8	72,270	218,000
7/28-8/4	Partnership field	Agali	Planting	6	2.8	3.0	19,140	60,000
33days		3 farms		41.7	34.0	51.5	282,150	762,000

<2> Rice farming on shared land

Table III.1.3 and Table III.1.4 present statistics for activities on shared fields. 7 tons of rice were harvested in 10 acres of shared land, for a rate of 1.75 tons / hectare. If this can be sold as seed rice for 4,000 Ush/kg (¥136/kg) to NaCRRI (Namulonge Crops Resource Research Institute), as planned, sales revenues of 28,000,000 Ush (¥952,000) can be expected. Subtracting expenses from this, Mr. Okullo obtained a profit of approx. 13,500,000 Ush (¥459,000) and Mr. Bosco a profit of approx. 11,700,000 Ush (¥397,800).

Even if the rice were not sold as seeds, but instead milled at a cost of 150 Ush/kg (approx. ¥5/kg; calculated based on weight after milling) and sold at a price of 2,000 Ush/kg (¥68/kg), this would be expected to earn sales revenues of 8,410,000 Ush (¥285,940) and a profit of 5,700,000 Ush (¥193,800).

Table III.1.3. Use of power tiller on shared land

Date	Owner of Field	Location	Activities	Size (acres)	Transport fuel (L)	Acticity fuel (L)	Fuel cost (UGX)	Labor cost (UGX)
5/10-18	Partnership field	Agali	1st ploughing	9.9	7.6	16.0	77,880	194,000
6/12-7/3	Partnership field	Agali	2nd ploughing	10.2	8.3	13.4	71,610	200,000
7/7-14	Partnership field	Agali	3rd ploughing	10.8	8.1	13.8	72,270	218,000
7/28-8/4	Partnership field	Agali	Planting	6	2.8	3.0	19,140	60,000
				36.9	26.8	46.2	240,900	672,000

Table III.1.4. Income and expenditures for shared land

	Total	Mr. Okullo	Mr. Bosco
Leased land			
Seeds		From previous period	
Machinery	900,000	Privately-owned	
Operator costs	672,000		672,000
Fuel costs	240,900		240,900
Harvest, threshing	430,000	215,000	215,000
Drying, winnowing	80,000	40,000	40,000
Bags	90,000	45,000	45,000
Drying sheets	160,000	80,000	80,000
Transport costs	75,000	37,500	37,500
Loading, unloading	73,000	36,500	36,500
Total expenses	2,720,900	454,000	2,266,900
Sales revenues	28,000,000	14,000,000	14,000,000
Profit	25,279,100	13,546,000	11,733,100

<4> Contract farming (hire service)

While Mr. Okullo worked in shared fields, he also performed hire services for 8 other people. Rental revenues of 2,780,000 Ush (¥94,520) minus fuel costs and daily wages to operators resulted in a profit of 2,012,660 Ush (¥68,430). Power tiller use for activities other than hire services incurred maintenance and repair costs of approx. 400,000 Ush (¥13,600), but hire profits managed to cover these machine costs. (Table III.1.5 contains statistics on power tiller hire services.)

Table III.1.5. Activities of Power tiller hire services

Date	Owner of Field	Location	Activities	Size (acres)	Transport fuel (L)	Acticity fuel (L)	Fuel cost (UGX)	Labor cost (UGX)	Service charge (UGX)
5/3	NaCRRI	Agwata	2nd ploughing	1.0	0.0	1.0	3,300	20,000	100,000
5/19-23	Alip Denis	Amac	Final ploughing	10.0	0.0	11.7	38,610	200,000	1,000,000
5/25-26	Okello Alfred	Amac	2nd ploughing	3.0	3.2	4.9	26,730	60,000	300,000
6/9	Moses Oremo	Barr	Planting	1.0	3.1	1.1	13,860	20,000	100,000
6/10-11	Dr. Opio Patrick	Itek-Okile	2nd ploughing	2.5	1.9	4.1	19,800	50,000	250,000
6/18-19	Dr. Opio Patrick	Itek-Okile	Puddling	2.0	2.8	2.8	18,480	40,000	140,000
7/31-8/2	Alip Denis	Amac	2nd ploughing	1.7	1.7	2.0	12,210	35,000	170,000
8/9-11	Ogwal Alfred	Amac	2nd ploughing	2.0	1.6	2.4	13,200	40,000	200,000
8/23	Padi	Agali	Transporting simsim	0.0	0.0	2.1	6,930	5,000	20,000
9/4-5	Dr. Opio Patrick	Itek-Okile	2nd ploughing	1.0	5.1	1.9	23,100	20,000	100,000
9/30-10/3	Bosco Kabengo	Agali	Final ploughing	4.0	2.0	4.4	21,120	80,000	400,000
26 days	8 people	8 farms		28.2	21.4	38.4	197,340	570,000	2,780,000
								Profit	2,012,660

3) Power tiller and implements: Status and issues

When Mr. Okullo received the power tiller and implements from 3WM Uganda at the end of April, he faced the following problems.

(1) The trailer was not large enough to carry the implements and other equipment.

(2) There was no proper length of connecting rod between the trailer and the power tiller, making it insufficiently flexible.

(3) There was little room between the power tiller and the trailer, making it inconvenient for the operator to sit and drive.

(4) It was not possible to connect the moldboard plough, disc plough, or seeding machine to the power tiller.

(5) The engine oil and gear oil had not been changed.

Mr. Okullo himself performed the oil changes in (5). AEATREC engineers were dispatched to Lira District to handle (4) and do the bare minimum necessary to enable the power tiller to use these implements.

Later, in the eight months from May 2015 to the end of December 2015, approx. 400,000 Ush was used on maintenance and repair costs (Table III.1.6).

Table III.1.6. Power tiller maintenance and repair costs

Maintenance / repair location	Summary	Maintenance / repair cost (Ush)
Engine oil (monthly pace)	26,000 Ush x 8 times	208,000
Screws	16,000 Ush first time + 30,000 Ush second time	46,000
Pulleys	Once	40,000
Farrow wheel	Once	60,000
Seeder	Once	40,000
	Total	394,000

Mr. Okullo conducted oil changes himself. What he could not do himself he had repaired by engineers from China Machines (Lira District branch), which sells Chinese-made power tillers. Engineers from ARETREC came to Lira specifically to handle seeder repair.

4) Farming to which is provided the power tiller hire service

In terms of hire service fees this fiscal year, Mr. Okullo collected 100,000 Ush per acre for ploughing and sowing, and 70,000 Ush per acre for flooding and tilling services. Last fiscal year, he collected an average of 85,000 Ush per acre as rental fees, but increased maintenance, repair, and operator labor costs prompted an increase in rental rates. The rate increase was further motivated by the fact that the market price for cow ploughing is 100,000 Ush per acre.

Statistics are provided below for four customers to which hire services were provided last year.

① Olwel Ben: 2,039 kg of rice (Nerica 4) harvested from 2.3 acres. 1,924 kg sold for 5,772,000 Ush. No farming this year due to returning to school.
② Florence: 832 kg of rice (Namuche 1) harvested from 1 acre. 782 kg sold for 3,519,000 Ush. Decided against using hire services this year due to timing mismatch with Mr. Okullo.
③ Ireda Primary School: 6,773 kg of maize (DK9090) harvested from 7.8 acres. This is used for school lunches. This year, they switched to hiring four-wheeled tractors.
④ Alele Fred: 344 kg of sunflowers harvested from 2 acres. All sold for 395,600 Ush. Requested hire services even with the higher prices, but cancelled due to mismatched timing. In reality, their sales revenues and hire service fees are almost equal, so they may have refused due to low profitability.

Hence, for a variety of reasons, these four did not use Mr. Okullo's hire rental services this fiscal year. Instead, Mr. Okullo provided hire service to another eight people. Information on three of those people are provided below as examples.

① Dr. Opio Patrick

Dr. Opio Patrick is a doctor and Mr. Okullo's brother-in-law. With Mr. Okullo's support, Dr. Opio attempted for the first time to farm rice on a 3.5-acre plot. Including rental fees, his expenses totaled approx. 4,500,000 Ush and have already yielded a harvest of 5 tons, with an expected another harvest. After inspection by NaCRRI, if it is possible to sell seeds, sales revenues could be expected to reach approx. 20,000,000 Ush with a profit of over 15,000,000 Ush. Even if the sale of seeds is not possible, the rice can be expected to be milled and sold for a sales revenue of 6,000,000 Ush at 5 tons, yielding an expected profit of 1,500,000 Ush. Although startup costs like clearing the land and building fences were necessary this time, this will not be necessary in the next planting season, meaning that higher profits can be expected.

Table III.1.7 Expenses in Dr. Opio's rice farming

Seeds	300,000	
Fertilizer	160,000	
Herbicide	144,000	18,000sh x 8L
Slashing	0	
1st plow	160,000	manual labour
2nd plow	250,000	PT
3rd plow	350,000	PT 100,000 M100,000
Paddling	380,000	PT140,000, Manual labour 240,000
Planting	300,000	
Weeding	440,000	1st 240,000, 2nd 200,000
Bird scaring	120,000	
Harvesting	315,000	
Threshing	30,000	5000x6
Drying & winowing	68,000	2000x34sack
Transport	660,000	20,000x30days, 30,000x2days
Sack	48,000	1200x40sack
Taplin	60,000	
Construction	390,000	soil 320,000, labour 70,000
Irrigation	170,000	Fuel 100,000, trench water channel 70,000
Fencing	156,500	Wire 110,000, pole 1500x31
Total	4,501,500	

② Mr. Ogwal Alfred

Mr. Ogwal attempted rice farming on a small scale in 2014, and began rice farming in earnest in 2015. At that time, he requested that Mr. Okullo perform 2 acres of ploughing. Including hire service fees, he spent 1,300,000 Ush on rice cultivation and brought a harvest of 1.9 tons. Because Mr. Ogwal operates his own produce store, milling the rice could be expected to bring in sales revenues of 2,300,000 Ush, yielding a profit of 1,000,000 Ush.

③ Mr. Alip Denis

Mr. Denis has been involved in rice farming for over ten years. This year, he used 2.5 acres for rice cultivation, and hired the power tiller for ploughing and paddling services from Mr. Okullo. In addition to rice, this year he also planted maize, sunflowers, sorghum, beans, sesame, soybeans, and cassava over approx. 10 acres. Some of this produce is still in harvest, but present sales revenues total 5,000,000 Ush.

Examining these farms who made use of hire services, those which grow rice and other highly marketable (i.e. high-return) crops can make a profit even using hire service, but it is difficult to make a profit with sunflowers and similar. Moreover, it is also apparent that low-marketability (i.e. low-return) crops require a certain level of total planting area in order to be profitable.

5) Hearing on the benefits of using agricultural machinery

Power tiller owners and service-hiring farmers were interviewed on their opinions on the benefits of using agricultural machinery. Below are some of the answers received.

- The power tiller is faster than manpower or Oxen power, and there are few things that can impede work. With manpower, work is often impacted by health and events like weddings, funerals, etc., making it difficult to manage progress. Using cattle is also time-consuming and the Oxen get tired, making some work stoppages inevitable.
- The power tiller's work is more uniform and consistent than manpower or cattle, in addition to higher yield.
- Although the amount of product that people or cows can transport is limited, a trailer can be attached to the power tiller to carry a substantial amount of harvested produce and other items.
- Although machinery requires maintenance and repair, machines only require fuel and they do not tire and stop working like people or cows. Moreover, considering that people and cows also need food, they require a lot of time and effort outside of the work itself.
- Although the four-wheeled tractor digs up deep soil and covers the surface of land with soil that is not appropriate for planting, the tractor-configuration power tiller digs to just the right depth.
- The four-wheeled tractor is heavy and crushes the soil, destroying bugs and other small organisms. Therefore, it is necessary to increase the amount of fertilizer inputs in order to achieve the same size harvest as is obtainable throug HP loughing by manpower or cattle power.

The table below compares data on the number of days spent ploughing and hire service fees per acre.

Table III.1.8 Comparison of ploughing and hire service fees per acre

	Manpower (2 ppl.)	Cattle ploughing	Power tiller
Ploughing	4 days	2-3 days	Half-day
Hire service fees	80,000	100,000 Ush	100,000 Ush

If a farmer is planting highly marketable (i.e. return) crops, he can expect higher profits from power tiller use. Compared to ploughing by manpower or cattle power, the power tiller is more efficient and is more cost-effective. For Lira District farmers, the power tiller is still new, and it seems that many people feel it is out of their reach because they rarely see power tillers used. However, the power tiller users have often come to appreciate the benefits of using a power tiller.

6) Prices of highly profitable agricultural produce

Below are the average selling prices per kilogram of produce as reported by 23 individuals visited during the hearings last fiscal year and this fiscal year.

Table III.1.9 Average selling prices per kilogram

Crop name	Price / kg (Ush)
Chia seeds	5,000
Sesame seeds	4,056
Rice (Milled)	2,427
Beans	1,663
Soybeans	1,273
Rice (Unmilled)	1,081
Pidgeon peas	1,000
Millet	950
Sunflowers	941
Groundnuts	933
Sorghum	693
Maize	563

The per-acre value of standard crops grown in the Lira District are listed below.

Table III.1.10 Per-acre value of crops

Crop name	Value / acre (Ush)
Rice (wetland rice)	1370,956
Rice (dry land rice)	925,458
Chia seeds	675,000
Cotton	620,000
G-nuts	618,486
Banana	533,333
Sesame seeds	521,169
Soybeans	510,840
Maize	425,894
Sunflowers	402,498
Sorghum	399,792
Cassava	393,333
Sweet potatoes	375,000
Beans	265,333
Millet	256,143
Pidgeon peas	220,000

In terms of value per acre, rice ranked the highest. Moreover, there is substantial room to improve the size of the harvest, as in many cases farmers were negligent in their weeding or failed to use fertilizer in order to save costs. There is also a great deal of inefficiency in the post-harvest threshing process, which is still performed by hand. Introducing a threshing machine would improve processing and could be expected to increase returns.

7) Impressions in comparing power tiller owners and non-owners

A hearing was conducted of 11 power tiller-owner farmers and 12 power tiller non-owner farmers in order to compare differences in the state of their farms' business. Because rice was predicted to be a highly marketable (i.e. high-return) crop, the hearing of power tiller non-owners looked only at rice farms who owned at least 8 acres of usable land. When power tiller owners were compared to power tiller non-owners, several trends were apparent.

①To power tiller owners, agriculture was not a primary occupation but a side-occupation. They had monthly income from their professions as doctors, school administrators, shop managers, etc. They put their savings from this income into farming. By contrast, 80% of power tiller non-owners had

side-occupations in land rental and property rental, but agriculture was their main occupation, and their source of income was unreliable.

②When asked about weekly or monthly household expenses and budgeting, most power tiller owners could answer immediately. In cases where they were unable to answer, some of those involved families operating shops or restaurants whose personal and professional lives were intertwined such that they took their necessary goods home from their business, or in the case of restaurants ate at their business, etc. This left them unable to precisely answer questions about household expenses and budgeting, but their costs were nonetheless covered by their own businesses. By contrast, most power tiller non-owners did not have a grasp on their household expenses. In order to estimate their weekly expenses, it was necessary to ask them how much meat, oil, soap, and other goods they consumed, and to calculate their expenses together with them. Even those who had taken out loans and were behind in repayment would simply divert household funds from their businesses when necessary, without even making an entry in the account ledger, and hence they were not certain of the state of their businesses' cash flow in terms of sales, expenses, etc.

③Power tiller owners had higher average revenue than power tiller non-owners, suggesting that their grasp and skillful use of both business and household cash flows led also to greater household

Because the current system in place by agricultural machinery sellers in Uganda involves no warranties or post-sale support, it can be predicted from the above that introducing a post-sale machine warranty and farm management support system would have a positive effect on the effective utilization of machinery and improve farm management. Training for sellers on the use and maintenance of power tillers is also important, in addition to the establishment of a supply system for machine maintenance services and spare parts. Further training on topics such as creating business plans and farming plans as well as how to keep a ledger could serve as value-adding services that help power tiller-using farm owners to succeed. In other words, these systems and structures of machine sellers have an important role to play for machine buyers in the process of achieving mechanization in agriculture. This study served to link agricultural machine manufacturers with second-hand retailers, leading to distributor agreements with sales scheduled to begin in February 2016. There are great expectations that Japanese-affiliated companies can spread agricultural machinery to parts of Uganda that have still not undergone agricultural mechanization, leading to the further development of Ugandan agriculture and the Ugandan economy.

2. Tanzania follow-up study

1) Agricultural reform in Tanzania

The Tanzanian Government established a "domestic rice production growt HP lan" in 2009, the year when the Government established the Agriculture First (Kilimo Kwanza) policy. In the plan, a target of 1.9 million tons by 2018 was set as the rice production volume by commercializing the rice production. The rice cultivation methods in Tanzania comprise 74% by rain-fed farming, 20% by upland farming, and only 6% by irrigated farming and 94% of the production is borne by the small farmers owning 0.3 ha to 2 ha of land[15] individually.

The annual gross production volumes of grains were 6.7 million tons in 2012, 7.6 million tons in 2013, and 9.8 million tons in 2014. The annual production volumes of rice were 1.2 million tons in 2012, 1.3 million tons in 2013, and 1.7 million tons in 2014. The annual production volumes of corn were 5.1 million tons in 2012, 5.3 million tons in 2013, and 6.7 million tons in 2014[16].

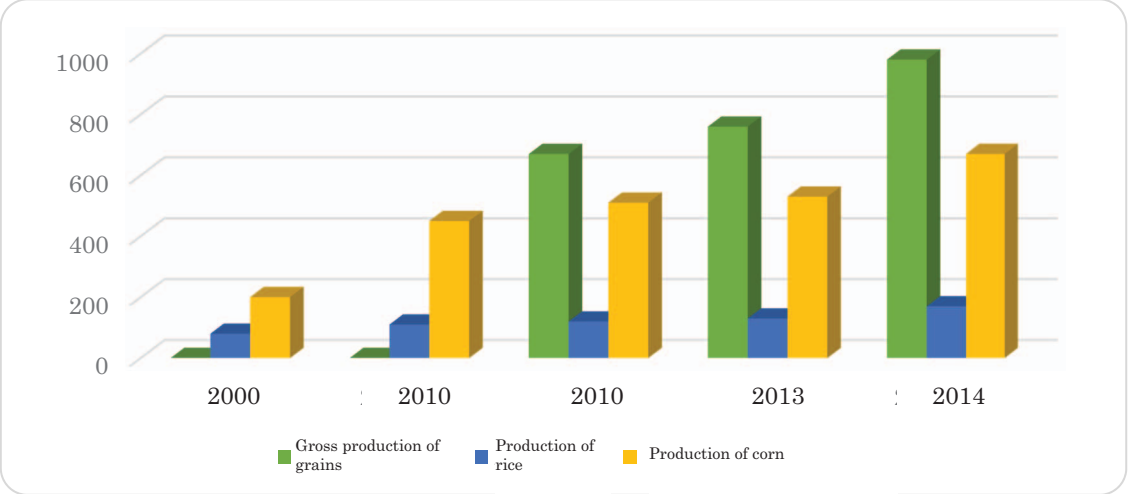

Figure III.2.1 Production volumes of grains, rice, and corn in Tanzania

2) Trend of mechanization

The use of tractors reached 14% (10% in 2006) in 2013. This enabled an increase of farmlands and reduced the manual work (70%) to 62%. The Ministry of Agriculture of Tanzania is focusing on the promotion for private companies to acquire agricultural machinery. The trend of mechanization of the private sector and the history of imports are provided below:

[15] Agricultural forestry industries and fisheries of Tanzania

[16] Report from the Agriculture Working Group

- In 2013, the private sector imported 916 tractors and 828 power tillers.
- In 2013, SUMA JKT GUARD Ltd. (Government-commissioned project) imported tractors (New Holland and Farmtrc) by using the low-cost loans from the Government of India and is selling them to farmers, farmers groups, and union communities in cash and loans domestically. The performance records show that the company sold 1,846 units and ordered 268 units.
- In 2014, the private sector imported 1,212 tractors and 393 power tillers.
- In 2014, the Government purchased 64 combine harvesters, 36 threshers, and 16 reapers through the Policy and Human Resources Development (PHRD) and brought them into 14 schemes domestically to increase the production volumes and reduce the waste at rice harvesting. (*Reference: These equipment units were brought into three schemes, Ipatagwa, Uturo, and Mbuyuni of Mbarali Prefecture of Mbeya.)
- In 2014/2015, through the discussion between the Tanzanian Government and the Polish Government, the Tanzanian Government received loans for starting a tractor assembly and agricultural machinery factory. The production is controlled by SUMA JKT on the Tanzanian Government side and by Pol-Mot Holdings S.A. Ursus on the Polish Government side. (See the photograph of the tractor of Ursus below.) (*In 2015, Ursus established a factory line in Ethiopia.) (*Blue-chip company that has been manufacturing agricultural machinery, and so on: Information through the Internet)
- In 2014/2015, the Tanzanian Government allocated the loan of 6,382.80 million Ksh to the Agricultural Inputs Trust Fund (AGITF) for the purchase of agricultural machinery.

Table III.3.1 Loan status from July 1, 2014 to March 30, 2015:

Loan type	Implementation		Amount (Tshs)
	Target	Execution	
New tractor	84	94	4,015,386,824.50
Pembejeo, and so on	50	21	949,700,000.00
Power tiller	23	1	7,242,000.00
Rice milling machine	8	2	57,000,000.00
Irrigation machinery	4	3	142,800,000.00
Reaper	2	-	0
Tractor maintenance cost	-	1	9,985,000.00
Total			5,182,113,824.50

Source: Agricultural Working Group Report, 2014

3) Irrigation schemes and rice farming of Mbarali District, Mbeya

In Mbarali District, there are 4 large irrigation schemes (3000 hectares or more) and about 30 small-to-medium irrigation schemes. Large irrigation schemes vary in the management style (public company or cooperative). For instance, in Kapunga Rice Project Ltd (3200 hectares), Export Trading Group is engaged in leasing of farm fields to neighboring farmers and also the lease service for tractors and combines, while being directly engaged in rice cultivation in paddy fields. The tractor lease/cultivation charge is 800,000 Tsh/6 hectares. Farm fields are leased to farmers at the rate of 1.5 million Tsh per block, which is 6 hectares.

For rice planning, about 150 workers are mobilized simultaneously for random transplanting. The wages for rice planting work are between 6000 and 10,000 Tsh per worker. However, at a peak time, the wages may increase up to 20,000 Tsh/worker due to the shortage of workers. Basically, unhusked (paddy) rice can be sold through any channel and rice can be processed by the drying/rice milling equipment that is owned by the company.

For the Madibira Smallholder Irrigation Scheme (3300 ha), an agricultural organization (MAMCOS: Madibira Agri. Marketing Cooperative Society), which is formed by 3,300 farmers as the members, selects management members to implement the management. Incidentally, for large irrigation schemes, a Rotavator is installed in a large tractor (equivalent to 80 HP) and a plough is not used.

For small-to-medium irrigation schemes (300 to 1000 ha), the cultivation area of most farmers is less than 1 ha and the main crops are rice and corn. For ploughing, animal power tiller, and large tractors are used.

Although irrigation facilities are well equipped, most of the farming relies on rainfall and the cultivation schedule and areas are determined by the volume of water flowing into the rivers. Incidentally, the best rice planting season is between December and February.

The Igomelo irrigation scheme (area of 450 hectares, 614 farmers) applies a unique agricultural operation in Murabari District. While in most schemes, farmers earn their livings by single-crop rice farming, many crops are grown by the Igomelo scheme including onions, corns, and tomatoes in addition to rice. The Bena tribe, which migrated from Njombe District of Irringa and settled in this land, is farming the paddy fields of 150 hectares and vegetable fields of 400 hectares or more. The results of the rice cultivation technology mastered through KATC/MATI can be observed everywhere. In particular, the checkrow planting (20 cm or 25 cm) technique are applied by most farmers, contributing to the improvement of yields.

Although cultivation by using cattle is employed as the insurance when a power tiller fails, the method is used for puddling by using a two-animal towing rake after ploughing with a power tiller. Puddling takes 4 to 5 days per hectare and costs 30,000 Tsh. However, according to older farmers, not many farmers can use cattle these days. Traction by Zebu Oxen (2-Ox towing) with an iron blade and chain is widely used for ploughing.

Table III.3.2 Irrigation scheme names and study districts in Mbarali District, Myeya Area

Scheme name	District Village name	Total area (ha)	Cultivated area (ha)	Crop type	No. of farmers	Agricultural machinery owned
Igomelo	Lugelele Igomelo	450	312	Onions, Paddy maize, Tomato	614	P/ tiller 23
Mbayuni	Mapogoro Mabayuni, Mbadaga	3,000	1,500	Paddy	1170	P/ tiller 123, tractor 5
Majengo	Igrusi Chamoto	1,300	550	Paddy	294	-
Kapunga Small holder	Itamboleo Kapunga	875	875	Paddy	875	P/ tiller 31, Tractor 11
Kapunga Rice Farm project	Itamboleo Kapunga	3,200	3,200	Paddy	1*	Tractor 18 C/harvester 6

Source: Extract from Agricultural Machinery Statistics 2013 of the Bureau of Agricultural Machineries, Mbarali District

* Under Kapunga Rice Project Ltd, Export Trading Group (ETG)

Table III.3.3 Combined harvesters distributed to Mbarali District through the PHRD fund

Irrigation scheme	Kubota DC-60	Korean branded Daidone	Total
Ipatagwe	4	3	7
Mbayuni	8	3	11
Utoro	ND	ND	ND

Table III.3.4 Transition of loan statuses and prices of power tillers Unit: Tsh

Year	Japanese branded	Chinese branded	Remarks
2011	7.000,000		Loan amount 11,000,000, iron wheel, trailer, plough, rake, and storage pump. House as the collateral. Paid up in 3 years.
2011	7,000,000		Loan amount 11,000,000, as above
2012	9,000,000		Loan amount 13,500,000, as above
2012	9,000,000		Loan amount 14,000,000, as above
2012	9,000,000		Loan amount 12,000,000, as above
2015	7,300,000 (8,100,000)	4,000,000	FE distributor (Mbarali District) ( ): Price delivered at the distributor

*Storage pump is the attachment of the power tiller.
* The creditor is SACCOS.

4) Research on the power tiller utilization/operation statuses

(1) Background and overview of the research

Owners of power tillers can be power tillers dedicated owner or transportation dedicated owners. For ploughing/soil preparation, disc plough and rakes are used for mainly paddy fields and farmlands. In a dry season, power tillers are often used for transportation. In Mbarali District, transportation of agricultural products and machinery by horses and cattle, which is frequently observed in other areas and Kenya and Uganda, are not seen. Instead, power tillers are widely used and fully-loaded traction-type trailers are often traveling at high speed. The types of loads vary including water, firewood, unhusked rice, building materials, and pasture grass and some travel back and forth over a distance of 100 km.

Mbeya rice has a high reputation as brand rice in neighboring countries (Kenya, Zambia, and Congo) as well as within Tanzania and the demand is increasing. Within Mbeya, the Mbarali District is the primary rice-producing district and mechanization is progressing rapidly. In the secondary (2014) research, the present conditions of rice farming and mechanization in this District were examined. In this research, the utilization statuses and actual operation conditions of cultivation in Igrusi district and Ubaruku district were examined twice, once in a dry season (June and July) and once in a wet season (November and December). The services/distributors and the spare parts supply structure in these districts were also examined.

In the research of utilization/operation statuses, 54 power tiller owners were selected and routine behaviors were recorded by attaching GPS to each operator. The table below shows the analysis of the effective data from the records.

(2) Result of the research

In a dry season, transportation (unhusked rice, water, and building materials) is the main work. As a result of tracing the behaviors of 8 power tillers (all of them were manufactured by Kubota) for 8 days in the Igrusi district, the average number of operating days was 5.6 days (2 to 8 days), the average number of operating hours per day was 9.3 hours (4.9 to 14.2 hours), and the average traveling distance per day was 33.6 km (8.3 km to 74.7 km). In the Ubaruku district, 9 power tillers were traced for 7 days and similar results as those of the Igrusi district were obtained.

Among the power tillers used for averaging a traveling distance, the power tiller that traveled 74.7 km was used for transportation of unhusked rice. It made a return trip for a distance of 50 km and the average number of hours was 14.2 hours. The charge was 2000 Tsh per bag of unhusked rice (80 kg) and 8 bags were transported by a trailer in total.

In a wet season, power tillers are mainly used for ploughing and soil preparation of paddy fields. For rain-fed rice fields, ploughing starts after rainfall and puddling (raking) is carried out when sufficient water is filled in the paddy fields. In the irrigation scheme, ploughing and soil preparation are carried out at once by installing a rotavator in a large tractor. In the wet seasons also, power tillers are used for transportation (water, compost, bricks, firewood, charcoals, and pasture grass) by using a traction-type trailer.

Table III.3.5 Utilization statuses in the dry season by using GPS survey

District	No. days in research	No. of units targeted for the research	Main work	Average number of days	Average traveling distance
Igrusi	8 days	8 units	Transportation	5.6 (70.3%)	33.6 km
Ubaruku	7 days	9 units	Transportation	6.1 (76.4%)	45.4 km

Note:
No. of days spent for the research: Igrusi District: June 20 to 27, 2015, 8 days
Ubaruku District: June 23 to 29, 2015, 7 days
Location of research: Igrusi (Majengo village), Ubaruku (Mkombwe village)

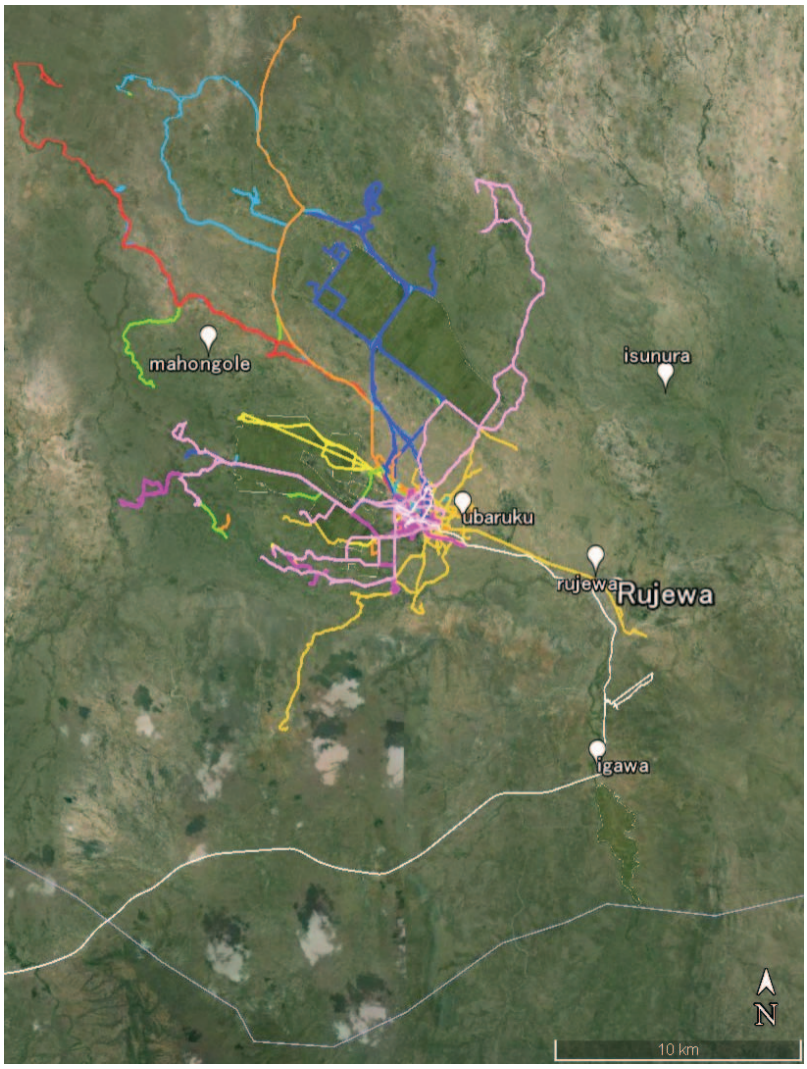

Figure III.3.2 Track log of GPS
(Each color means each power tiller user's activity in trial period)

5) Local agricultural machinery distributor and parts supply status

The agricultural equipment distributor that is managed by Mr. Nizary Duzzu (Iranian), is located in Chimala of Mbarali District. It has branches in Mbeya, Mbarali, Ubaruku, and Igrusi.

The distributor distributes products from Farm Equipment (Head Office: Dar es Salaam, importer and distributor of various types of agricultural equipment and machine tools). The power tillers include those manufactured in Japan, AMEC (AM140 manufacturers in China), CREAVES (GS140 manufactured in India), and large 4 wheel- tractors that are manufactured in Japan (50 to 80 horse power; Sonalika manufactured in India (50 to 90 HP)) are exhibited on the shop front.

According to Mr. Nizary, the owner, the annual sales of power tillers were 50 units in 2011, 150 units in 2012, 200 units in 2013, 400 units in 2014, and 400 units in 2015 (300 units manufactured in Japan and AMEC 100 units). Incidentally, the distributor started to handle Japanese branded power tillers from 2013.

The sale prices of power tillers are 6.7 million Tsh for Japanese branded products, 4.2 million Tsh for Chinese branded products, and 4 million Tsh for Indian branded products and the sales commission is 7.5%.

While the price of Japanese branded power tillers was 5 million Tsh (with plough and rake) in 2007, the price in 2015 was 8 million Tsh (main unit only). They seems to be sold at around 10 million Tsh at the street value.

Although the main spare parts are stored in the warehouse, customers purchase Chinese branded parts since Japanese branded parts are expensive. Customers select cheaper parts because they cannot differentiate Chinese branded parts from Japanese branded parts. Even if the advantages of Japanese branded parts due to the high quality and durability are explained, customers do not understand the difference (comment from the shop owner).

Table 7 Prices of main parts

Names of main spare parts	Thai – Japanese branded	Chinese branded
Clutch cable	35,000	
V—belt (one)		15,000
Piston		150,000
Piston ring		30,000
Clutc HP ulley	65,000	30,000

6) Bank loan (CRDB: Cooperative Rural Development Bank)

Summary of loan conditions:

① To be registered by the group leader (individual acceptable)

② Has an account in CRDB.

③ Prepare and submit a group member list.

④ Submit an arable land certificate.

⑤ Deposit 25% of the loan amount in the bank.

⑥ Collateral (house, arable land, etc.)

⑦ The loan period is 1 to 3 years and the interest rate is 17%.

Farmers prefer to use SACCOS for its more generous loan conditions. However, the management condition of SACCOS itself is deteriorating and many organizations are halting the business. On the other hand, banks apply strict loan conditions and in particular, submission of certificates of arable lands is problematic for farmers since they usually inherit lands over generations so that not many lands are registered publicly. Therefore, some application documents are incomplete.

7) Discussion

This section discusses the features and issues of power tillers that are widely used in Tanzania based on the verification tests, supplementary research, and subsequent follow-up tests and research results.

(1) Skill training

Skill training for operators is essential. However, the contents of training need to be re-examined. For instance, farmers and operators need to master basic skills such as how to release air, replace elements/filters, perform routine inspection, and maintain operation records. The mastering of engine disassembling and assembling skills is regarded as unnecessary. Often neglected broken equipment is seen without being repaired after it has been disassembled by the operator without the necessary tools or skills. Disassembling without adequate facilities or skills causes loss of parts and damage, thereby reducing the life of the machinery. Rather, it is more desirable to entrust the equipment repairs to skilled engineers and automobile (including bicycle) maintenance shops and agents that are equipped with the tools required for maintenance and to provide mechanical maintenance skill training to engineers engaged in such organizations and to enhance the service.

(2) Maintenance management

Enforcement of regular inspection and utilization records are essential for maintenance management. However, owners and operators neglect routine maintenance management, giving priority to lease business. As a result, regular part replacement (element, filter, etc.) is not carried out

and engine oil is simply refilled instead of being replaced with new oil by completely draining the old oil.

Spare parts whose damage conditions can be checked visually (belt, pulley, and cable/wire) are purchased/replaced or welded/repaired (cables are handled with strings). However, since genuine parts cannot be obtained easily (expensive or distributors do not have genuine parts), cheaper imitations are used. There are many cases where equipment has been left unrepaired after being disassembled by operators without adequate skills under the environment without necessary tools. Many operators tend to disassemble hastily without thinking of the consequences so that training and education are essential.

(3) Driving

(a) Damage on gears

Accidents causing damage to gear cases and gears are occurring frequently. Probably, such accidents may have been caused by changing gears while traveling (tractors are not designed to change gears during traveling). Power tillers need to be stopped before the gear is changed. It is necessary to provide guidance on safe driving and accurate operation in operator training.

Through the operator training, it is also important for operators to learn the basic knowledge of tractors in addition to maintenance/driving. Disassembling/assembling of engines cannot be mastered in a short period and must be limited to the minimum necessary skills to be mastered for maintenance.

(b) Tire size and traveling speed

Among the countries that were targeted by the research under this project, the specific feature of power tillers in Tanzania was the tire sizes. The products of all the manufacturers that are sold in Tanzania (Thai Kubota, AMEC, CREAVES) use 14 horse power engines and tires of 7.5 to 16 inches (same size as that of Land Cruiser). (Ordinary power tillers use tires of sizes from 5.0 to 13 inches.)

Photo III.3.1 Installed large tires

According to the distributor, the reason for using such large tires is to move to neighboring farm fields by climbing over ridges and if the vehicle is too low, moving becomes difficult for ploughing.

The power tillers have the advantages of better handling over uneven road surfaces and better acceleration. On the other hand, momentum caused by traveling at high speed restricts brake control, resulting in frequent overturn or contact accidents.

In the agricultural off-season, power tillers are used for transportation (trailer) of unhusked rice, drinking water, and construction equipment. While the maximum speed allowed by the Road Traffic Law in Japan is 15 km per hour, the result of the GPS test shows the speed range from 40 km to 50 km per hour is the normal traveling speed range in Tanzania.

Rims (hub bolt, see the photographs) have been damaged due to overloading and most rims have been reinforced.

Photo III.3.2 and III.3.3 Rim reinforcement

(c) Clutches and tension pulleys

In the Igurusi District, a tension pulley is removed from most power tillers and the clutch is directly connected to the main pulley. Since the operation for transferring power gradually is absent in this case, the power is immediately connected to the drive section, causing the vehicle body to jump suddenly. According to the operator, a tension pulley has low durability and pulleys were replaced many times. At the moment, operators do not see any problem even if a tension pulley is removed. There are risks of accidents (sudden jumping) caused by direct connection to the clutch.

Photo III.3.4 Tension pulley

(4) Other agricultural equipment units

There is a local company that imports/sells used agricultural equipment. The company is mainly handling tractors and general-purpose combines. Most Japanese branded power tillers are equipped with a rotavator and since the stock in Japan is becoming low, the import rate is decreasing.

The company is selling rice transplanters (walking type and riding type). There is no sign of transplanters being used and they are stored in the warehouse. Japanese branded manufacturers do not export rice transplanters. However, Japanese branded products that were manufactured in China have been brought in and since no technical guidance has been provided, the investment on the equipment has become wasted.

(5) Japanese branded products and products made by competitors

For the power tillers that are widely used within Tanzania, three manufacturers are monopolizing the market, Thai Kubota, Chinese manufacturer (AMEC), and Indian manufacturer (CREAVES). Above all, the price of the product manufactured by Thai Kubota is twice that of the Chinese branded

product. In spite of the high price of the product manufactured by Thai Kubota, the number of units sold accounts for 50% of the total.

The power tiller is equipped with plough, rake, and trailer as the standard attachments. Moldboard plough (bottom plough) or disc plough are widely used and power tillers with a rotavator are the minority (large tractors are equipped with rotavator and are used for irrigation paddy fields).

Photo 5 From the left: Made in India, Made in China, Made by Thai Kubota

Photo 6 Product made in China (left), which is identical to the product made by Thai Kubota (right)

3. Summary

1) This agribusiness deployment and promotion substantiative research model business has been exploring the possibility of mechanization in small-scale rice growers in Uganda, Tanzania, Kenya and Ethiopia in East Africa with an aid by the Ministry of Agriculture, Forestry and Fisheries of Japan since 2013. We kept in mind reduction of poverty of farms and public-private partnership.

Though demand for rice has been increasing rice production has been correspondingly growing in and Sub-Saharan Africa areas, the production does not meet the demand, pushing up imports. With such a current situation, Japan presented a plan to double production of rice for 10 years from 2008 and established CARD (Coalition for African Rice Development). Countries have been working together, achieving some positive results. Nevertheless, one of the reasons why production does not meet demand is poor production efficiency due to dependence of small-scale farms on human power for rice growing.

2) As rural areas of Sub-Saharan Africa chronically has redundant labor force in general, it is thought the areas are suited for agriculture using the labor force, especially rice growing requiring intensive labor. In fact, as to a series of operations from tilling to planting (rice planting), weeding, pest control, reaping and postharvest processing, in a situation where there is no choice but to depend on meteoric water, proper time is limited. As a result, the cost of labor of seasonal workers increased, which contributed heavily to poor competitiveness with imported rice. Furthermore, young people as a major labor force will not take agricultural work, disliking such human-powered work. As one of the solutions to break through such a situation, we conducted a survey on orientation and possibility of agricultural mechanization realistic for small-scale farmers.

Thinking introduction of power tillers is realistic for mall-scale farmers, we conducted substantiative research from the aspects of labor productivity and costs, and hearing investigation about the usage situation as to work efficiency of human power and power tillers.

3) In three countries where we conducted substantiative research to compare power tillers and human power with slightly different situations, the operation capability of power tillers was higher that of human power in terms of time while it was nearly equivalent in terms of cost. As agricultural work is completed faster by mechanization with the costs being equal, introduction of power tillers is well worth. This is because it is expected that planting (rice planting) can be completed in proper time, which contributes to improved labor productivity.

Problems are financing for purchase and improving annual availability factor. Issues are an operator’s ability and system of repair and part supply etc. As to financing for purchase, a financing facility is insufficient. If at all, it is often for small-scale farms to borrow funds. Though there is any public funding for collaborative purchase, it is not accordingly operated well. Eventually, a method in which well-heeled farms purchase machine and lease the machines for cultivation is practical and has

been widespreading gradually. Successful cases are seen in which leasing machines to surrounding farms for cultivation is practical for improvement of annual availability ratio and conveyance and motivity are applied to both cultivation and harvesting. The public sector will expand opportunities for training to improve operator's abilities and private dealers will assume that role. The dealers have a major role to play in providing repair and supplying parts, but it does not pay unless the whole agricultural implement market grows.

4) Looking at the importance of work efficiency, harvesting is more important for reaping r time. As to harvesting, man-powered harvesting and man-powered husking prevail. In this regard, we compared labor productivity by man power, combination with a reaper and husker, and a combine and we obtained a result that machines are more excellent in labor productivity and both are nearly equal in costs. From this result, it is thought that possibility of introducing power tillers will expand. We did not consider combines at the beginning of the project. However, as they play an active role in production bases in Tanzania, Lower Moshi. Kenya and Mwea, we compared man power and a combine. As a combine is more expensive, it is difficult for small-scale farms to buy it and commercial capital farms lease it to them. In many cases, they can use it sufficiently seeing them as users. Mechanization may progress faster in this way. As occurring in Japan and East Asia, mechanization slightly different from mechanization poverty progresses in which small-scale farms are equipped with capital and mechanized gradually.

5) Postharvest storage and improvement of rice polishing techniques are also major issues for competitive success against imported rice. Aside from large-scale rice mills, knock-off versions of SATAKE's rice mill machines made in China prevail in small- and middle-scale rice mills. Higher rice cracking rate due to overdrying is problematic, but stone removing is more problematic. Stone contained in rice shipped from rice mills is removed by man power at markets, which cannot be said perfect. Appropriate stone removing machines must be introduced with improved rice polishing techniques.

6) Unlike in a decade ago, the basis for introduction of agricultural machines has been formed. In Africa, no one repairs a machine as it is if it breaks. Because parts were not sufficiently supplied, supply of agricultural machines was avoided even with Japan's free financial and technical aid. However, the rapid spread of automobiles and mobile phones of recent years has had a hugely positive effect on the basis for introduction of agricultural machines from the aspects of training of repairmen and spread of information. It is amazed by the situation makers in China and India advanced into the market while Japanese public and private sectors were slightly hesitating to supply agricultural machines. In a surveyed city, some shops sell agricultural machines made in China and India. The problem is the poor quality of these machines. This may make people to review the quality of machines

made by Japanese makers and buy them even at higher prices, but in many cases, it just led to an evaluation that small agricultural machines such as power tillers were not useful.

7) Firstly, it is required to understand the current situation of agricultural mechanization in Africa accurately for thinking the development of agribusiness in the areas of Sub-Saharan Africa through public-private sector collaboration. In that context, it is significant that public and private sectors conduct a survey like this project for a long term. Comparing with East Asia and Southeast Asia, the road to the spread of agricultural mechanization of small-scale farms in these areas is a long one. However, opportunities must not be missed as mechanization has been rapidly gathering as evidenced by this survey.

Secondly, cultivation and recruitment of human resources must be focused on. As well as cultivation of human resources at field levels such as education for extension staff, cultivation of repairmen and training for salespeople of shops, advertisement for those involved with decision of policies such as improvement agricultural financing is important. Cultivation of human resources in public and private sectors in Japan is also important. Not many people understand the current situation of agricultural mechanization in Africa and actively contribute to reduction of poverty and sustainable development of small-scale farms. Private sectors can recruit Japan Overseas Cooperation Volunteers as village development staff members. In addition, local NPO organizations and human resources must be actively used as agents.

Thirdly, selection of agricultural machines appropriate for each agricultural land and crop is important. We proposed procedures for mechanization appropriate for dry-rice cultivation in Uganda and wet-rice cultivation in Tanzania, Lower Moshi. Kenya and Mwea, respectively through this survey. Mechanization appropriate for each land must be carefully thought as soil conditions and agricultural machines to be used are different even for the same wet-rice cultivation in the same country. The order of introducing machines must be flexibly thought. As among machines for production, weeding, harvesting and postharvest processing, rice mill machines are introduced earlier than ones for production (there are many such cases actually), it must not be thought comprehensively.

Finally, we point out the importance of follow-up. In ODA of Japan, projects for agricultural mechanization in the areas of Sub-Saharan Africa were conducted between the late 19080s and the 1990s. However, no enough follow-up for these projects was provided, which, as a result, caused a delay of private makers in Japan in entering the market. Bot only efforts on the hardware side such as supply of parts but also follow-up for human resources are important.

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