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 –First Year-

March 2014

JAICAF ジェイカフ

Japan Association for International Collaboration of Agriculture and Forestry

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 a hindrance. 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, dispatched specialists from Japan to implement an agricultural mechanization feasibility test for small scale farmers and survey of the current state of mechanization. As for the feasibility test, we conducted a test by introducing a power tiller to a upland rice farm located in swampy areas in Uganda which used rainwater for growing rice. Based on the NGO's power tiller introduction case, we researched durability and changes in farming. As for the survey of the surrounding situations, we examined information related to the mechanization in Uganda and Tanzania. In this project, we specially dealt with mechanization issues in both countries and their efforts to tackle these issues. As the result of these activities, we came to realize some mechanized farming improvements and some technical issues.

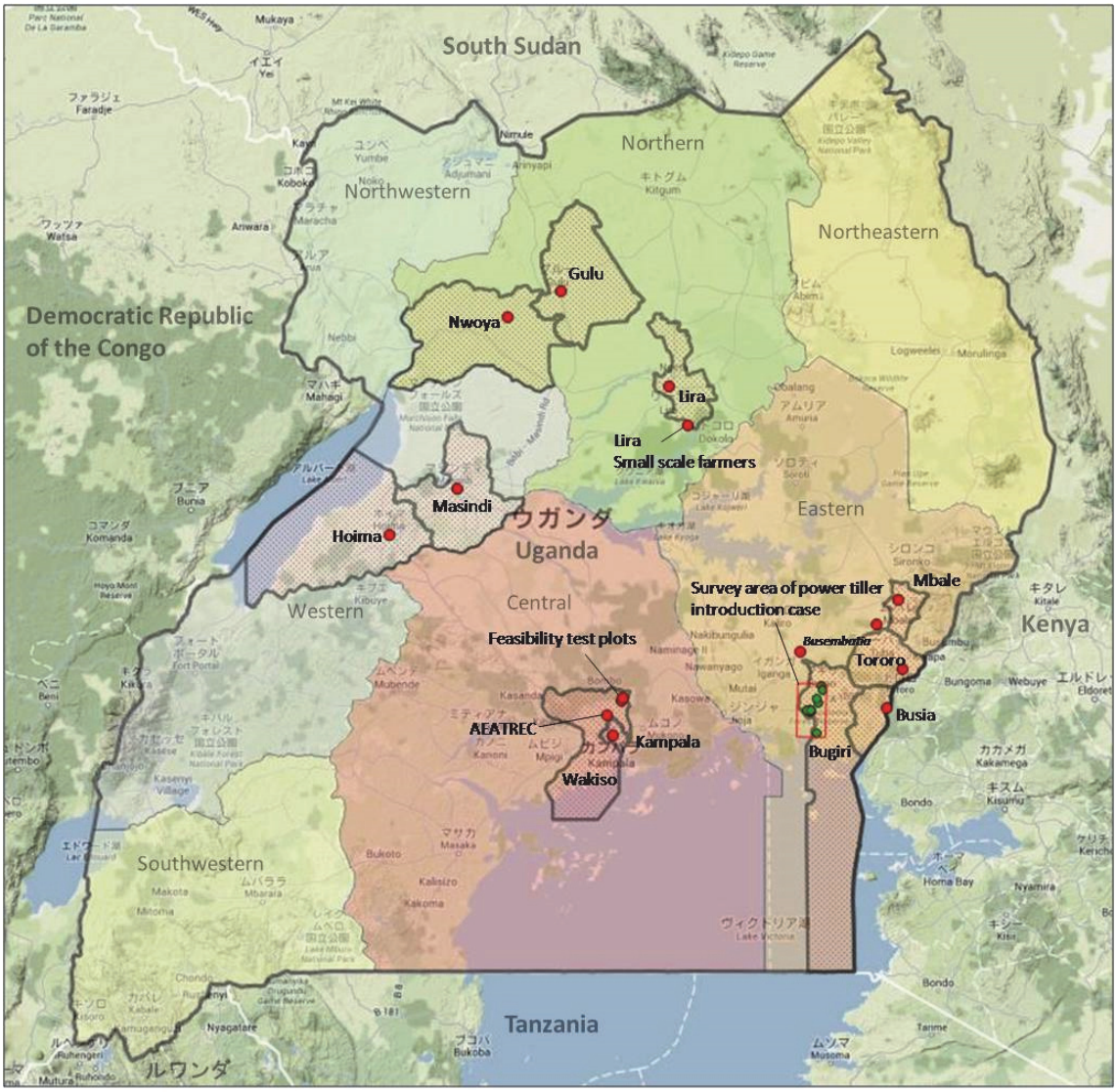
In this report, we put together the outline and the results of the above activities. We expect that our project results will contribute to the mechanization of the region and also be utilized by private companies as well as international cooperation related parties. We will be pleased if our report is 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 head quarters gave us guidance and advice on planning of this project and the evaluation study. Furthermore, for the activities by our specialists in the countries in concern, we received cooperation from the Japan International Cooperation Agency, Uganda Office, Rice Promotion Project for Hunger and Poverty Reduction in Uganda, and National Agriculture Research Organization of Uganda affiliated Agricultural Engineering and Appropriate Technology Research Centre. 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, 2014

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



Project Map

JAICAF made the map based on “UGANDA – UBOS District Shapefile（District boundaries 2012）”, “Uganda Districts Information Handbook Expanded Edition 2011-2012” and Google Physical layer.

(http://www.fspmaps.com/dataportal/content/uganda-ubos-districts-shapefile：access date March 12th 2014)

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Abbreviations List

ACE	Area-Cooperative Enterprise
ACF	Agricultural Credit Facility
AEATREC	Agricultural Engineering and Appropriate Technology Research Centre
AICAD	Project for Construction of African Institute for African Development
AO	Agricultural Officer
ASA	Agricultural Seed Agency
BAIDA	Bugiri Agri-business and Institutions Development Association
CARD	Coalition for African Rice Development
CHAWAMPU	Chama cha Wakulima wa Mpunga
DADP	District Agricultural Development Plan
DSIP	Development Strategy and Investment Plan
EAAPP	Project of the Eastern Africa Agricultural Productivity Program
FAO	Food and Agriculture Organization
FIP	Framework Implementation Plan
IAEA	International Atomic Energy Agency
IFAD	International Fund for Agricultural Development
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
KADC	Kilimanjaro Agricultural Training Centre
KADP	Kilimanjaro Agricultural Development Project
KATC	Kilimanjaro Agricultural Training Centre
KNCU	Kilimanjaro Native Cooperative Union
LMIS	Lower Moshi Irrigation Scheme
LOMIA	Lower Moshi Irrigators Association
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MDGs	Millennium Development Goals
MFIS	Micro Finance Institutions
MSC	Microfinance Support Center Ltd.
NAADS	National Agricultural Advisory Service
NAFCO	National Agricultural and Food Corporation
NARL	National Agricultural Research Laboratory
NaCRRI	Namulonge Crops Resource Research Institute
NAP	National Agriculture Policy
NARO	National Agriculture Research Organization
NDP	National Development Plan
NEC	National Enterprise Corporation

NIS	Ndungu Irrigation Scheme
NUAC	NorthernUganda Agricultural Centre
NVTI	Nakawa Vocational Training Institute
RPO	Rural Producer Organizations
RYMV	Rice Yellow Mottle Virus
SAA	Sasakawa Africa Association
SACCO	Saving And Credit Cooperative Organizations
SACCOS	Saving and Credit Cooperative Society
SAGOT	Southern Agriculture Growth Corridor
SIAD	Sustainable Irrigated Agriculture Development Project in Eastern Uganda
SUA	Sokoine University of Agriculture
TICAD IV	Tokyo International Conference for African Development IV
T.Shs	Tanzania Shilling
UBOS	Uganda Bureau of Statistics
UCA	Uganda Co-operative Alliance Ltd.
UCSCU	Uganda Cooperative Saving and Credit Union Limited
UNIDO	United Nation Industrial Development Organization
UNRDS	Uganda National Rice Development Strategy
USAID	US Agency forInternational Development
Ush	Uganda shilling
VECO	Vredeseilande Country Office
VLSA	Village Savings and Loans Association
WARDA	（現 Africa Rice Center）
WFP	World Food Program
WUA	Water User Associations
ZARDI	Zonal Agricultural Research and Development Institute
ZARI	Zanzibar Agricultural Research Institute

1 USD = 2,508.94Ush (http://ja.exchange-rates.org/Rate/USD/UGX, 2014/03/12)
1 USD = 1,626.06T.Shs (http://ja.exchange-rates.org/Rate/USD/TZS, 2014/03/12)

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ANNEX

Chapter 1 Project Report Summary

1. Purpose of Project

In the region of sub-Sahara Africa, the number of undernourished people accounts for a high percentage of about 30% of the whole population. Moreover, poverty and starvation are increasingly serious problems in this region due to the hikes of food prices worldwide in recent years. To solve these problems, it is important to ensure the food security in this region and reduce poverty. The measures to achieve these objectives include promoting increase in agricultural products and improvement of their productivity through direct investments in agriculture which is the key industry in sub-Sahara Africa.

Based on this recognition, Subsidized Project of the Ministry of Agriculture, Forestry and Fisheries, "2013 Model Project for Demonstration of Development and Promotion of Agribusiness in Sub-Sahara Africa" (hereinafter referred to as this project) was implemented with the aim of promoting investments in agribusiness targeting farmers in the region of sub-Sahara Africa as well as increasing incomes of local farmers and reducing poverty by conducting a demonstrative experiment to increase production volume of agricultural products and improve their productivity through investments in materials and equipment, including agricultural machinery which was introduced in the region using a rental or leasing system.

2. Contents of Project

As the target countries of this project, Republic of Uganda (hereinafter Uganda) and the United Republic of Tanzania (hereinafter Tanzania) were selected from the countries located in sub-Sahara Africa. In Uganda, a demonstrative experiment and its supplementary research were conducted. In addition, in Tanzania, a supplementary research of the demonstrative experiment was conducted to promote investments in agribusiness for farmers in a wider area in the sub-Sahara Africa region.

In this demonstrative experiment, power tillers, grain threshers and rice milling machines were introduced mainly to farmers engaged in growing upland rice to verify the performance of each agricultural machine and to what extent those machines could contribute to the improvement of productivity of labor. In Uganda, as there were farmers who had already introduced power tillers made by a Japanese manufacturer, research was conducted on what changes in the operation of farming those farmers have experienced after introducing power tillers and what issues they have in relation to durability and operation of the power tiller.

In the supplementary research conducted along with the demonstrative experiment, information was collected which was necessary for introducing agricultural machinery with the aim of increasing incomes of farmers. In addition, a training session was held during the period of dispatch of the project

team to provide local farmers and technical experts with instructions and education on how to use and manage agricultural materials and equipment.

From these activities, basic information necessary for the development and promotion of agribusiness operated by private companies and other parties was collected in this project. Report on the outcome of this project was prepared based on the demonstrative experiment result, the result of its supplementary research and the result of review by a committee of knowledgeable key figures. In addition, as general reporting on the project outcome, a seminar was held targeting parties involved in manufacture of agricultural machinery and in international cooperation projects to share the vision for the future investment direction among interested parties.

3. Summary of Project Results

1) Feasibility experiment

The demonstrative experiment in this project was implemented in cooperation with AEATREC and Promotion of Rice Development Project which is operated by JICA within NaCRRI located in Kyaddondo County, Wakiso district in Uganda. In this experiment, a farm field for seed development and other farm fields around it within NaCRRI were leased and two work areas were set in these fields; one work area using machines and another with human power for growing upland rice in rainfed lowland. By comparison of these two areas, it was evaluated how labor productivity changed as a result of introducing machinery in stages of plowing, cultivation (weeding) and harvesting. In this experiment, power tillers (rotary and tractor types), reapers, grain threshers and pneumatic separators were used. A test of rice milling machines was also conducted using rice crop.

As a result of the experiment, working time was shortened and productivity of labor was improved in all processes of rice cultivation. It was revealed that in agriculture in Uganda which is suffering a labor shortage, mechanization of plowing was economical even with a cost of fuel, and that expansion of farm lands was possible. Efficiency in weeding work which is a heavy burden on farmers was also improved to the same extent as plowing work. At the same time, issues faced with farmers when actually introducing machinery were identified. In the experiment in the stage of harvesting, reapers have remarkably improved the efficiency and it was highly appreciated by farmers. In addition, in working with grain thresher and pneumatic separator, not only the working time was shortened but also harvest loss was prevented, which means that higher efficiency is expected than the result values indicate. Furthermore, in the experiment of rice milling machine, it was found that mill top type of rice milling machine was more effective in shortening working time and reducing energy cost in comparison with the Engelberg type.

As stated above, agricultural machineries introduced in the demonstrative experiment in this project have improved the labor productivity in each process of rice cultivation. Although improvements are required in some areas since a system of mechanization is not fully established and operators have not

sufficient skills, it was indicated that farm mechanization can contribute to expansion of scale of farmers involved in rice cultivation. On the other hand, effect of mechanization on crop yields per unit area which was not clearly found in this experiment and how much increase in incomes will be expected if agricultural machineries were continuously operated and whether it will lead to reduction in poverty are the issues to be addressed.

2) Follow up of introduction of power tiller

In this project, research was conducted focusing on farmers in Nankoma area (sub-county), Bugiri district who purchased power tiller made by a Japanese manufacturer with the financial aid from VECO, an NGO in Belgium. In addition to basic information regarding income, cultivated acreage and growing products, changes in the operation of farming brought by the introduction of power tiller and the durability of power tiller were also researched, which were difficult to grasp fully from the experiment in the farm fields described above.

The most significant change brought by introduction of power tiller was the expansion of cultivation acreage about four times as a result of improvement in labor productivity. The farmers had increased income by obtaining charges from renting power tiller for the use by neighboring farmers in their cultivation works, as a source power of a corn sheller, etc, and as a vehicle by connecting with a trailer to transport crops, construction materials and water for domestic use. As a result of improvement in labor productivity by using power tiller effectively, some farmers spent more time in faming or in participating in union activities, etc.

As for durability of power tiller, research was conducted by visiting the area several times and found that the core mechanism, engine and gearbox of power tiller were without any failure but failures were found in the clutch lever and the connecting part with a trailer as well as significant wearing of consumable articles (i.e. V belt and rubber tires). As supply of spare parts is difficult in rural areas, farmers dealt with these problems by using alternative articles or asking a local blacksmith for repair. Half of the farmers who had power tiller received training on how to use and manage power tiller but improvements were required in maintenance. Although most of the failures were minor, a failure or wearing arising from lack of understanding by users on proper maintenance may lead to more serious disorder. To prevent this, further instructions on maintenance and management of power tiller were deemed necessary. Based on this observation, in addition to the training on how to use and manage power tiller provided for its owners, training for repairpersons and mechanics in and around this area was provided in this project.

With regard to repayment of purchasing fund, we received the answer from farmers that they can repay the loan for purchasing cost by due date by using power tiller not only for plowing but also for providing source power, transportation, etc. to earn rental charges. Although some farmers had a risk of delay in repayment due to the effect of drought or insufficient management of operators,

introduction of power tillers has shown the effects in expansion of cultivation acreage, reduction of labor burden and increase of income and, at the same time, issues to be handled to ensure proper operation of power tiller were identified.

3) Supplementary research

In Uganda, basic information necessary for development and promotion of agribusiness operated by private businesses was collected from hearing and materials from concerned organizations, private companies and farmers. Main items of information obtained are listed below.

(a) Overview of agriculture productions centering on rice cultivation

(b) Overview of farm economy and status of farm economy in Namulonge area, Wakiso district and Nankoma area, Bugiri district.

(c) Policy and current status of farm mechanization

Dissemination status, channel of distribution, sales price, repair of machines

(d) Agricultural finance, in particular, current situation of finance for small scale farmers

(e) Social and cultural background in Uganda

In Tanzania, similar research was conducted as in Uganda to obtain general overview of current situation of farm mechanization and obstacles as well as understanding the fact and trend of government policies and sales strategies of private companies in the field of farm mechanization from hearing from concerned organizations, private companies and farmers.

Chapter 2 Research Result on Development and Promotion of Agricultural Mechanization

1. Current situation of agricultural mechanization

1) Overview of agricultural mechanization

The level of agricultural mechanization in Uganda is lower than those in the neighboring countries. It is said that 90 percent of the plowing depends on human power, and 8 percent and 2 percent depend on livestock and machines, respectively. In the field of agricultural mechanization, efforts have been made to introduce tractors particularly into the estate agriculture since the pre-independence days. However, the area for privately owned land is limited, and the agriculture is based on a self-sufficing family labor. A machine has hardly been owned by an individual farmer, on the one hand. On the other hand, the Government-led hire service system (tractor hire service) has long been used by part of the farmers. Since the end of 1980s, this system has been privatized as part of the structural adjustment project implemented by the World Bank. However, this project is not accepted as a private business in Uganda suffering from lack of human resources as a result of long civil war. Many of about 4,000 tractors once operating in this country were said to have been sold to the neighboring countries such as Kenya, with the result that the number of the tractors operating in this country was reduced to a half. After that, there has been a gradual increase in the number of the machines. According to the indicator of the World Bank, the number of the tractors is estimated at 4700[1] during the period from 2004 to 2007. In the meantime, the Food and Agriculture Organization (FAO) estimates the number of tractors within the country of Uganda at 2420. When this is divided by the arable land area of 6,050,000 hectares, the number of tractors is 0.4[2] per 1000 ha. This figure indicates a great departure from 20 tractors per 1000 ha as recommended by FAO. This figure is much lower than 1.3 tractors per 1000 ha, representing the average figure of sub-Sahara African countries.

After 2007 when attention was focused on a world-wide food crisis, investment was made not only in the resourceful countries in Africa but also in the sub-Sahara African countries. As a result, there has been a continued economic growth of more than 5 percent a year. Uganda is also favored with continued excellent investment environment

[1] http://www.tradingeconomics.com/uganda/agricultural-machinery-tractors-wb-data.html

[2] FAO (2009) Statistical Yearbook 2009. http://www.fao.org/docrep/014/am079m/pdf/am079m00a.pdf

due to long-term stabilization of the Government under President Museveni and verification of the petroleum resources. In the east Africa, prior investment has been made in the field of agriculture in Kenya and Tanzania. In Uganda, there is a trend of increasing investment in the field of agriculture. The nominal GDP per capita is estimated at 595.9 US dollars[3], and the agricultural labor cost is also expected to increase.

The maize and cassava said to have been the staple food have been processed into powder. This has resulted in a spread of flour milling machines. In the meantime, in response to the upland rice cultivation having made a rapid progress since 2000, an increasing number of rice-cleaning machines have been introduced even in the areas other than the eastern area noted for a booming paddy-rice cultivation. Small-scale rice mills are estimated to have been installed at more than 600 business establishments[4]. Further, there have been a growing number of medium- and large-scale rice mills. The volume of domestically grown rice to be processed has been increased, and the quality has been improved. However, in addition to the privately owned processing machines, there are many small-scale processing machines introduced according to the program of the Government support granted to farmer groups. This does not necessarily represent a private-sector-led mechanization based on the principle of market economy.

2) Experimental research of agricultural machinery

A test laboratory for the agricultural machine is found in the Agricultural Engineering and Appropriate Technology Research Centre (AEATREC) established under the control of the National Agricultural Research Laboratory (NARL) under the umbrella of National Agricultural Research Organization, NARO). This organization was established in 1949. The major research activities cover 4 fields; farm power and mechanization system, farm-level agro-processing for value addition, renewable energy system, and water harnessing and utilization. Further, this Center as a research laboratory provides a training site for about 20 students of 4 national universities.

The test of the agricultural machineries is assumed to be on the same level as training, trial manufacture and manufacture of agricultural implements, technological support

[3] Word Economy Database. http://ecodb.net/country/UG/

[4] Promotion of Rice Development Project. (2013) Rice in Uganda: Viewed from Various Market Channels, A Survey Report. http://libopac.jica.go.jp/images/report/P1000013336.html

and other activities. The objectives and significance of the evaluation test intended by the Government of Uganda are to evaluate the performances under the solid conditions specific to this country, and to certify the technological specifications claimed by the manufacturer, and to provide the related sectors with proposals on the technological performances of the machine. The machines subjected to this evaluation test include a ride-on tractor, walking type tractor (with rotary), animal plow, transplanter, weeder, pest control machine, reaper and others. In the test, a cultivated field test is conducted after verification of the specifications and operation procedures, break-in operation, and adjustment for cultivated field test. The test is conducted on at least 4 different types of soils for 300 hours (by an hour meter).

The Center provides all the essential services expected from the agricultural machine test laboratory including, including research work, evaluation test, training, trial manufacture and technological support. However, the Center is staffed with only three researchers of agricultural machineries, and it is difficult to provide sufficient services in all the anticipated areas. The evaluation test is extremely important when viewed from the necessity of excluding the faulty products and selecting the machines best suited to this country, which is required to import multiple foreign-made agricultural machineries. Further, it is anticipated to find out the procedures for adjusting and operating the machines more suited to this country through the evaluation test, and to spread such findings to the users. The test record of a walking type tractor includes the details description of the specifications of this machine and working machines, conditions of the cultivated field, and machine conditions. The test consists of 2 major items; an efficiency test including fuel cost measurement, and a handling test. The test is considered to cover an adequate range when consideration is given to the current limited facilities of the laboratory. Since Uganda is located on highlands, verification of the output of the tractor (engine) to be imported is expected to be included in the scope of the evaluation test, although this assumes subsequent introduction and improvement of the measuring instruments. It must be pointed out that the test method and test procedures (including the list of the items to be checked in the handling test) should be recorded and documented.

3) Education and training institution

As an advanced educational institution for agricultural machineries, the Busitema University located in Tororo of the eastern part of this country is noted for its long history and good performance records. In 1971, this organization was the first to open up a

diploma course for agricultural machineries. A Bachelor course was added in 2007. It receives about 40 students every year. About 3/4ths of these students are allowed to graduate. In each of the 2nd and 3rd years of the Bachelor course, an external training internship is given for 10 weeks. In the 4th year, students are required to manufacturer an agricultural machine on a tentative basis in a graduation project. The training factory of this university consists of an engine training room, electric training room, welding/forging/heat treatment training room, and machine tool room. However, many of the equipment and materials are the products made in the former Soviet having been imported at the time of establishment, and are seriously dilapidated. After graduation, students are employed by the business companies or work as farmers. Another advanced educational institution is the Department of Agricultural & Bio-systems Engineering of the College of Agricultural and Environmental Sciences of the Makerere University well known in east Africa. This institution has excellent teaching staff for processing of the agricultural products, but is not sufficiently equipped with agricultural power machines. An occupational training school, the Nakawa Vocational Training Institute (NVTI) located in Kampala is noted for its best educational course with excellent facilities. This institution is placed under the control of the Education and Sports Ministry. Founded with the cooperation of Japan in 1971, the school has been providing a 9-month occupational training instructor course (consisting of 6-month classroom training and 3-month field training) since 2007. The training courses cover the fields of electricity, electronics, machine tools, cars, woodworking, sheet metal/lead pipe, welding and plaster work. 2 year training is essential before graduation. Each course receives about 25 students having been educated for 11 years. There is no course on agricultural machine. In 2000, however, the representatives of farmers were provided with a 1-month training course on machine tools jointly by the United Nations Industrial Development Organization (UNIDO) and Sasakawa Africa Association (SAA). Further, they were provided with a training course on the production of threshers, cassava processing machines and other simple agricultural machineries for farmers.

Jinja has the NGO-supported private Nile Vocational Institute, which provides training courses for car repair and tractor operations (where both operation procedure and simple repair technique are taught). This institute receives trainees twice a year, who have to attend a 6-month classroom training course and a 3-month field training course before graduation. This is a boarding school where the school expenses amount to 800 US dollars. About 10 trainees are currently studying there. The course is placed under the charge of the instructors having diploma. The teaching materials consist of the

secondhand tractors and other actual equipment donated by the Kakira Sugar Company in the neighboring area

4) Local production of agricultural machinery

There are not many manufacturers of agricultural machineries in this country. Most of the manufactured machines are simple small-sized products manufactured by welding. The TONETT Agro Engineering is an agricultural implement manufacturer located in Kampala. The major products are the agricultural processing machines such as cassava processing machine, maize flour milling machine, thresher and sorter. The machines for cultivated fields are manufactured only in a small volume but a wide variety of machines are handled. Machines are produced from limited materials by devising various manufacturing methods. This suggests that this company has a certain level of technique capable of producing parts other than the engine and gears, by the machine tools available at hand. However, some of these parts must be shop-adjusted, and a stable quality may not be ensured among the same model. The company receives orders from neighboring countries as well. However, they basically produce machines after receiving orders. They sometimes undertake a high volume production for donors and the Government. The engineers have rich experience since the owner was awarded with a diploma, but workers are self-made employees. One of the former employees of this company established an agricultural implement manufacturing company in the same business. This suggests that this business belongs to a growth industry.

The surrounding industry supporting the agricultural machine manufacturing business is not much developed. The steel materials of smaller thickness are regenerated from scraps in this country. The pulley is produced locally by aluminium casting using a sand mold. The local production of the cast iron product has not yet been observed. In the field of forgery, several blacksmiths are found out in Kampala. An order was placed with a certain company to manufacture the hatchet edge of a power tiller. Then the spring of a car tire was reshaped by tempering and the product was finished by hardening. However, hardening was made by fixing a wet cloth on the surface without temperature control.

Transmission parts such as bearings and chains have not yet been produced. The V-belts used here are the imported products, which are sold at the hardware store selling the imported tools. However, these products are not offered in a wide selection of sizes. For example, if the bolt of a desired size is not available, it is necessary to find it out in a secondhand market.

5) Agricultural machinery dealer

The imported agricultural machinery including a tractor is available from the distributors having entered into the sole agency agreement, and imported product sales shops. The distributors are Cooper Motor Corporation Uganda Ltd. (CMC) handing the CASE and New Holland, and Engineering Solutions Uganda Ltd. (ENGSOL) handling the Massey Ferguson. Other brands include Mahindra and Sonalika of India, and Foton of China. Many of the bands of the US and Europe have dropped by the wayside. The top selling tractor is an 80PS-class machine for cultivation. Many of these tractors are provided with a triple disk plow.

CMC has sold about 100 machines since the beginning of this year, as of September 2013, and is estimated as the biggest dealer in Uganda. It provides the customer with a 1-year quality warranty, and uses a traveling repair car to provide repair services in the event of a trouble. This company handles the Ford, Matsuda and Suzuki vehicles as well as large-sized truck, in addition to the tractor, and has a high-level repair shop. Further, 6 of the NARO-owned local workshops not being used will be modified to start repair services and operation training services. In the field of working machines, the company handles the Italian-made NARDI products. In the meantime, ENGSOL supplies the working machines for Tatu Marchesn and Agromaster Many of the smaller machines such as engines, power generators, reapers, power tillers and mill top rice cleaning machines are handled by Indian or Chinese dealers. They have about 10 shops in Kampala. Some of them have branch offices in local cities.

6) Private tractor hiring services

In response to the structural adjustment by the World Bank, tractor hire services were privatized in the 1980s. The National Enterprise Corporation (NEC) is a company set up in conformance to the 1989 law under the Government leadership by the Commercial Division of the Uganda Military Department. Its major activities cover construction, engineering, and hire services for car, electrical appliance, agriculture implement and tractor. In Kampala, the company under the name of NEC Tractor Project Ltd. provides services of selling tractors and others to the agricultural cooperatives and individual farmers, and tractor cultivation services. Starting the sales activities in 2008, the company has sold 200 tractors. In the case of direct purchase by the farmer, the company is financed by 20 percent from the investment of the farmer and the remaining 80 percent from the direct contract between the general band (such as Centenary Bank and Stanbic

Bank) and the farmer. During the reimbursement period, the bank has the property right of the machine. Since the tractor is assumed as a security, there is no need for further security. Financing is provided at an annual rate of 12 percent with the 2-year reimbursement period within the framework of ACF. The tractor purchased according to this framework is covered by a one-year quality warranty and parts are supplied by NEC free of charge during this period. The repair charges are borne by the farmer. In the cultivation service, the plowing work is done at 100,000 Ush per acre and the harrowing is done at 70,000 Ush per acre. The company has 4 branch offices (Iganga, Kiryadongo, etc.) in the country. The problem is found in poor farms and occasional delayed payment after the work. Some farmers request the work to be done without stone or stump being removed. This may damage the machine. There is a definite shortage of the repair shop with skilled workers. Local repair services (by traveling workshop) are also provided, but this requires much time and cost because the workers have to travel all the way from Kampala. The company has a tie-up with Iran and Turkey. Thus, Iran-made ITMCO tractors 75HP are used.

Northern Uganda Agricultural Centre (NUAC) is a company financed by the Danish capital. The company is located in the Province of Nwoya. Its activities range over the production on the agricultural land of 800 hectares, sales and repair of the agricultural implements, and processing of the agricultural product. The company is staffed by 10 leading people, and the farm manager is a Kenyan. Secondhand agricultural machineries are purchased from Denmark and are used in the production division. These machines are also sold to a customer whenever there is any. Further, the company provides parts sales service, parts repair service and operator training service. The major tractors consist of Models 90PS and 130PS, including two 250PS models. The combines are general-purpose machines, including 3 machines for maize, rice and soy bean having a header width of 6 m. The company is based on the large-sized mechanization system characterized by an integrated procedure including all the phases of the cultivation, seeding, biological control, manuring and reaping. The tractor uses a slit mold board, which is said to be more suitable than a disk plow. In the hire service charges, the mold board requires 140,000 Ush per acre, and the disk plow requires 80,000 Ush. the disk harrow requires 70,000 Ush per acre and the combine costs 200,000 Ush.

West Acholi Cooperative Union Ltd. located in Gulu was established in the 1960s, and has a farm land of 9000 acres. This organization is an association consisting of 99 cooperatives with a membership of 2,000. The major business is centered on cotton

production, ginning, production of oil stuff product and tractor hire service. 5 tractors are currently available. Of these, 2 are owned by Union. The remaining 3 are owned by the agricultural cooperatives which are its member organizations. The purchase of tractors were financed by the Asset Facility Loan of the DFCU Bank at an annual interest rate of 10 percent with the reimbursement period of 6 years. The periodic inspection of the products purchased from CMC is left to the care of distributors. In the hire service charges, the plow work for members costs 60,000 Ush which is lower than the market value of 80,000 Ush. Similarly, the harrowing service is provided at 45,000 Ush which is lower than the market value of 60,000 Ush. In the plowing service, 1,000 acres or more were plowed in the last season during the period from November to May, but part of the services had to be outsourced. When consideration is given to the number of members, the number of tractors have to be increased.

Some people provide hire services in the capacity of unincorporated enterprise, but the number of these people cannot be grasped at present. An owner-manager living in the suburbs of Kampala in the province of Wakiso has an experience of studying the agricultural mechanics in Delhi. He started hire services by repairing and regenerating a tractor which has been almost a scrap. In 2011, he paid 50,000,000 Ush to purchase the MF1135 manufactured in 1982. This machine was equipped with a quintuple disk plow. Further, he has 2 more tractors. His business is based on his own funds and the interest-free loan from this friend. His advantage is found in the repair technique. Accordingly, he also provides repair services. The plowing charge is 130,000 Ush per acre, but he undertakes the work at 80,000 Ush per acre if there are 100 acres in total. He has 2 full-time operators whom are paid on a piece rate basis. Work is concentrated in the period from January to March and from June to September. The problem is that many of the farmers place an order after the rainy season has come, and the work efficiency is lower in the land where there are anthills and stumps of trees. Another problem is the trouble of the machine. The charges are transferred via the mobile phone network.

7) Providing agricultural machinery through extension institutions

An agency in charge of widespread use of the agricultural technology is the National Agricultural Advisory Services (NAADS) placed under the umbrella of the Ministry of Agriculture, Stock Raising and Fisheries after the structural adjustment. This agency takes charge of establishment and growth of the agricultural organizations, and spread of the technology on specific agricultural products selected in the region. When an

agricultural organization wishes to start production and processing businesses, and has met specified conditions, such an organization is provided with a support through this agency to purchase tractors and rice cleaning machines. The equipment and material have failed to meet the management size because a sufficient plan was not worked out at the time of selecting the equipment and material.

So far, animal plows, sowing machines , rice-cleaning machines have been supplied to the group of farmers by the international NGO such as SAA in addition to Food and Agriculture Organization (FAO) and World Food Program (WFP). However, since technological support was not included in some of the support activities, some of the machines were not used after a trouble occurred to them, or the availability factor of machines were reduced in many cases. Machines are often provided free of charge when the Government support is granted. Accordingly, the businesses engaged in sales activities based on the principle of general competition assumes that the Government support is a menace to the market. Vredeseilanden headquartered in Belgium established VECO East Africa to support the hire service of the power tiller in the province of Bugiri. In this case, the machines are not provided free of charge. 2-year financing is granted to the farmer having prepared the down payment equivalent to the amount reduced by half. From the viewpoint of sustainability, expectations are placed on such a support to promote the independence of the group of farmers.

8) Machinery use amongst farmers

A great number of tractors are used in the sugar-manufacturing industry engaged in the estate agriculture as well as in the tobacco and oil stuff industries. Such business establishments are making efforts to educate tractor operators and to develop a basically self-sufficient system because they are provided with repair shops. Accordingly, the following introduces a farmer in the suburbs of Kampala in the province of Wakiso who has been enabled to use the power tiller through the support of NAADS, where the small-sized agricultural implement is employed. He owns a 30-acre land to cultivate strawberries, vegetables (qinggengcai (bok choy), tomato, pumpkin, garland chrysanthemum, etc.). The harvested vegetables are sold in the market of Kampala. The arable land area has been increased from 2 to 10 acres by the introduction of a walking type tractor. As for the cultivation work, since rotary equipment cannot be mounted, bottom plowing is performed 4 times (at an interval of about 1 week between the 1st plowing and 2nd plowing.) Both cultivation and harrowing are frequently performed. The business season is found particularly in November and December. This farmer has

owned a walking type tractor for the past 4 years without any trouble such as leakage of transmission oil or lighting failure. If a trailer (whose traction rod is currently in trouble) can be used, the operation time will be increased. Bottom plowing performed 4 times on the field cultivated every year does not appear to be high efficient. Harrowing by use of lake should be tried. Technological instruction from the viewpoint of adequate use will be required in this case.

9) Medium and large scale rice millers

Tilda is the company engaged in the biggest rice cleaning business in Uganda. According to the agreement signed with the Government on the use of commercial use of the irrigation project zone, this company is doing business in an integrated manner including all the phases of the rice production, rise cleaning and sales. The company uses 200 full-time workers on the 1,200-hectare paddy field, and the single harvesting is about 3.5 t/ha. Further, the company purchases paddies from the neighboring farmers of the project zone and cleans these paddies. The company owns about 20 tractors and 5 combines. Rice paddy plowing is performed by the 400PS-class tractor and disk harrow for the first time, by the 80PS-class tractor and Rotavator for the second time, and by the hydro Rotavator (walking type in super-compact configuration) for the third time. Harvesting is performed by a half-truck or a wheel type large-sized combine (an axial flow type having a blade width of 5 m). The blade is replaced at intervals of 1 or 2 years by the new one purchased from the United States. A partial small damage of the blade is not repaired. Rice planting is manually performed in strips, and weeding is performed by the hand-driven rotary weeder. A small-sized airplane is used to spray fertilizers. Further, the company owns a power tiller for tentative cultivation land. Thus, agriculture is implemented by a combination of such a large-sized machine and human labor. The rice cleaning facilities include a color sorter having an annual processing capacity of 10,000 tons, a large-sized rice cleaning system equipped with automatic weighing packaging device, a concrete drying site and a hot air dryer. A broken rice sorter is used to package only the broken rice for sales. It appears that the color sorter is not used or is used in a restricted manner because, after the red rice has been cleaned, red stripes remain on some portion of the rice.

A Chinese-made rice cleaning system is introduced into many of the intermediate-scale rice mills. The annual processing volume ranges from 3000 to 5000 tons. This figure is increasing in recent years. There are 2 types of business models. In one of them, rice is purchased while rice is produced. In the other model, only rice polishing is performed. In

the former model, the handling volume must be increased by purchase, and is accompanies by many problems such as a failure in rice collection in conformance to the management size, and a shortage of warehouse storage capacity. The latter model is found in the business of Upland Rice Miller Co. which was started in 2007 based on the fund including the USAID. The company has about 10,000 small-scale farmers as customers, and collects a rice cleaning rate of 160 Ush (1 US dollar equivalent to about 2500 Ush) per kilogram. However, the warehouse can be used free of charge. To increase the number of customers, the company has set up about 30 agents throughout the country to collect harvest season information and to give technological instruction. The company provides the grower with information for improving quality by the test mill and moisture meter.

10) Small scale rice milling machine

One of the staple foods in Uganda is posho (called "ugali" in Kenya) which is made by the process of putting maize powder into hot water and is agitated until water is removed and the contents are made solid. There are many flour mills in the village not supplied with electric power. Many of the small-scale rice cleaning businesses have diversified the business from milling to rice cleaning business. After 2000, upland rice cultivation developed even in the north and west where paddy-rice cultivation was not performed. There has been an increase in the number of small-scale rice mills. There are estimated to be more than 600 mills. Engelberg type mills are very rarely used. Models N-70 and N-120 as improved version of the Engelberg (with forced ventilation function) are frequently utilized. Further, mill tops SB-10, SB-30 and SB-50 account for almost 50 percent. Consumables such as a belt, rubber roll and screen are easily available in Kampala. After removing the hulls from rice by the locally made Engelberg machine, some of the companies use another machine to clean the rice. Use of a motor reduces the energy and repair costs than use of a diesel engine. However, due to frequently occurring power failure, many companies use an engine. The polishing charges vary greatly in the range from 70 to 250 Ush per kilogram according to the area because of different supply-demand balance conditions.

2. The Current State of Agricultural Credit

1) Introduction

In this report, we explain the current state of agricultural credit in Republic of Uganda (hereinafter referred to as “Uganda”) by looking at trends of agricultural lending from

commercial banks and other financial institutions, and based on a field survey targeting Savings and Credit Cooperative (SACCO) conducted in November 2013[5].

The structure of this report is as follows. Part 2 and 3 outline commercial banks in Uganda, overview of private financial institutions (including SACCO), main measures and policies regarding agriculture credit support, and trends of agricultural lending from commercial banks and other financial institutions. Part 4 introduced agricultural fund borrowing by farmers and their access to financial institutions, based on results of census study. Part 5 describes the overview of SACCO, a major financial institution in rural areas, and analyzes the actual situation of agricultural lending by SACCO. Lastly, part 6 clarifies the current situation based on the above description and indicates some of the future challenges.

2) Overview of Forms of Private Financial Institutions and Related Laws and Regulations

(1) Forms of Private Financial Institutions

Firstly, let's see the overview of private financial institutions, which accept deposits and perform other financial services[6]. Private financial institutions in Uganda are broadly divided into three categories (as shown in Table 2-1), i.e. (1) regulated financial institutions, (2) semi-regulated financial institutions, and (3) non-regulated financial institutions. Commercial banks are part of regulated financial institutions. Regulated financial institutions are classified into Tier I, Tier II and Tier III based on various elements, such as business affairs and amount of capital. SACCO and microfinance services by NGOs are part of semi-regulated financial institutions. SACCO is a co-operative financial institution that accepts deposits and channels those deposits into lending activities, which can be established by a group of minimum 30 farmers. Apart from regulated financial institutions and semi-regulated financial institutions, there are Village Savings and Loans Association (VSLA) and a number of non-regulated financial institutions, such as micro-financing companies.

[5] The Japanese for SACCO in this paper mostly written with reference to JAICAF (2010).

[6] Written based on Masako Fujiie "Chapter III: Institutional Problems of Agriculture" in JAICAF (2010, Japanese).

Table 2-1 Overview of Financial Institutions

		Forms	Number of Financial Institutions	Number of Branches	Applicable Rules/Regulations
(1) Regulated financial institutions	Tier I	Commercial banks	24	496 (714 ATMs)	Financial Institutions Act 2004
	Tier II	Credit institutions	3	42	Financial Institutions Act 2004
	Tier III	MDIs (Microfinance deposit-taking institutions)	4	99	MDI Act 2003
(2) Semi-regulated financial institutions	Tier IV	SACCO (Savings and Credit Cooperative)	2112	N/A	The Cooperative Societies Statute 1991
		Microfinance by NGO, etc.	N/A	N/A	Non-governmental Organization Statute etc.
(3) Non-regulated financial institutions		VSLA (Village Savings and Loans Association), micro-financing companies, etc.	thousands	N/A	Laws and regulations are not applicable

Source: JAICAF March 2010 "Agriculture and Forestry in Uganda: Present Situation and Issues for Development 2010 Edition", Bank of Uganda 2012 , Annual Supervision Report, Ministry of Finance, Planning and Economic Development 2012, Evaluation Study of the Rural Financial Services Programme and the Uganda Cooperative Savings and Credit Union

(2) Laws and Regulations for Private Financial Institutions

Regulated financial institutions conduct activities based on Financial Institutions Act 2004, and The Bank of Uganda (the central bank) serves as the supervisory institution. On the other hand, there is no state regulation for non-regulated financial institutions, which are positioned as informal financial services.

As for semi-regulated financial institutions, all laws and regulations (The Cooperative Societies Statue 1991) regulating the co-operative apply to SACCO. Based on those laws and regulations, The Uganda Co-operative Alliance Ltd. (UCA), the national organization of all co-operatives, serves as the supervisory institution for SACCO.

Regulations that apply on SACCO are not only regulations related to financial services, but also regulations related to co-operative in general. Unlike regulated financial institutions, SACCO is not subject to the depositor protection scheme from the government. There are a little under 100 SACCOs that exist in Iganga District, where we conducted interviews. Of the figure, in the past year two co-operatives failed in their business operations, and collapsed. In these cases, depositors are not protected. In order to address this situation, financial regulations for SACCO and a new bill on depositor protection are being reviewed and a lot of attention is paid to future development of this issue.

3) The Government's Measures and Policies for Agricultural Credit Support and Trends in Agricultural Lending in Regulated Financial Institutions

In Uganda, farmers are classified into small and micro farmers who are engaged in subsistence agriculture; medium-sized commercial farmers who grow subsistence crop

and cash crop; and commercial farmers who conduct advanced agricultural production, marketing and processing. The Agriculture Modernization Plan designed by the Uganda Government in 2001 stated the aim of having 5% of commercial farmers, 25% of medium-sized commercial farmers and 70% small and micro farmers by 2017[7]. Therefore, we can presume that at present, small and micro farmers are the majority of the agricultural structure. In the following section, we will analyze the main agricultural credit policy in Uganda by associating it with the agricultural structure and see the trends of agricultural lending of regulated financial institutions that have clear data.

(1) Measures and Policies Through Regulated Financial Institutions

Financial institutions that specialize in agriculture do not exist in Uganda, but the government has implemented measures and policies for agricultural credit support through commercial banks (regulated financial institutions) and SACCO, one of the semi-regulated financial institutions. It should be noted that besides measures and policies of the government, various international support organizations in Uganda also offer assistance for agricultural credit.

As a part of measures and policies through regulated financial institutions, the government established Agricultural Credit Facility (ACF) in October 2009. ACF is a scheme in which the government finances half of the loan by regulated financial institutions with zero interest rate, and the government bears the credit risk of the part of the loan with zero interest rate in order to support the medium-and long-term financing for equipment for agriculture and agricultural products processing.

The financing conditions vary depending on the period, based on budgetary measures of the government. Since July 2011 the government has been financing half of the loan amount with zero interest rate, and the debtors' interest cost is fixed at 10% annually. The period for reimbursement of the loans (redemption period) is set to 8 years.

(2) Measures and Policies Through SACCO

Next, let's take a look at measures and policies through SACCO. Since 1994, Ministry of Finance, Planning and Economic Development has been receiving assistance from African Development Bank to provide support for microfinance. As part of these efforts, Microfinance Support Center Ltd. (MSC) was established in 2001.

By financing SACCO since 2010, MSC is providing funds necessary for SACCO to extend

[7] Based on classification of farmers in Plan for Modernisation of Agriculture, which was created by the Government of Uganda in 2001. Refer to pp. 12–13 in JAICAF (2010, English) for details.

loans. As of February 2013, the total loan balance of SACCO is 250 billion Ugandan Shilling (hereinafter referred to as USH), and 20% of the total amount is financed by MSC.

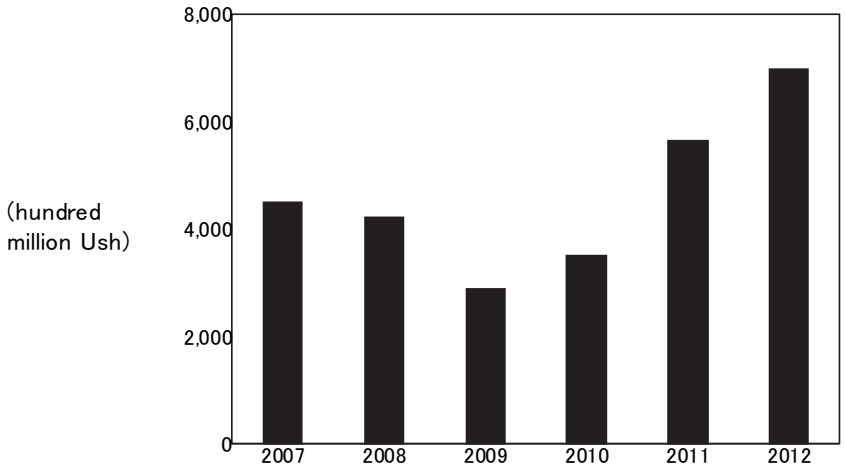
The terms of loans from MSC are as follows: 9% annual interest rate for agriculture purpose and 13% annual interest rate for commercial purpose, with the redemption period of 4 years maximum. However, 60% of the total loan balance of MSC (as of December 2012) is loan with redemption period of 1 year or less, so we can see that most of the provision of funds from MSC is short-term funds.

Although the financing from MSC to SACCO is not limited to agriculture purpose, around 70% of financing to SACCO is for agriculture purpose. According to interviews with MSC, when MSC extends loan to SACCO, there are many cases where it requires a personal guarantee from SACCO officers. MSC performs a review based on documents that prove assets of the officer and SACCO's balance sheet or other materials submitted by SACCO. The repayment rate of loans from SACCO to MSC is around 80% in 2012.

(3) Trends of Agricultural Lending by Regulated Financial Institutions

Let's review the recent trends of agricultural lending by regulated financial institutions and the current status of ACF scheme. Figure 2-1 shows the amount of agricultural lending by regulated financial institutions every year since 2007. Please note that the data is discrete because two new regulated financial institutions were established in 2011. Since 2009, there is an increasing tendency of the amount of loan. In 2012, a total of 699 billion USH loans were made. The ratio of loans from commercial banks is the highest, around 90% of the total loan. About 10% of total loan balance of commercial banks is for agriculture purpose, and the ratio tends to increase.

Figure 2-1: Trends in Amount of Loan Extended by Regulated Financial Institutions



Source: Agricultural Finance Yearbook 2012

Meanwhile, another breakdown on the total loans from regulated financial institution in 2012 shows that ratio of loan for industry purpose and processing purpose stays at 20% each, and ratio of loan for marketing purpose is the highest, around 60%. Furthermore, the breakdown in terms of redemption period is as follows: the period 1 year or less (short term) is the most common, which is 72.4%, followed by 1-3 years or less (mid term), which accounted for 19.9%. Long-term loans with more than 3 years period account for only 5.6% of the total loans.

As a factor of the small amount of long-term loans, it is pointed out that most of the water for agricultural use in Uganda is dependent on rainwater, so farming becomes unstable by bad weather. Thus, it is difficult for the farmer to repay debt, which makes the credit risk for long-term loan goes higher. In long-term financing, mismatch occurs in financial arrangements and fund operation period because the financial arrangements by regulated financial institutions are mostly liquid deposit. In addition, as the lending interest rates fluctuated a lot in recent years[8], long-term loans affected financial institutions, such as a higher interest rate risk.

It is presumed that most of agricultural lending from commercial banks is for large-scale farmers with large amount of loan, as we can see in the next section. Many commercial

[8] Commercial banks' lending rate (including that of non-agricultural loans) soared from around 5% in 2010 to around 20% in 2011, and fluctuated a lot to around 15% by the end of 2012.

banks are reluctant from lending agricultural loans to small and micro farmers because of the high credit risk, small amount of loan and high transaction costs[9].

When we look at the financing history using the government's ACF scheme, in one year period that began in July 2009, which recorded the largest amount, 20% of the total amount of agricultural lending by regulated financial institutions was extended using this scheme. Half of the funds were used for processing machinery (wheat, tea, coffee, etc.) or storage and other facilities, and only 30% of the funds were used for production machinery, which shows a low ratio. Financing using ACF scheme shows a large amount per loan with many of the borrowers being large-scale farmers, and the use by small and micro farmers is near zero[10].

Other than agricultural credit support through regulated financial institutions and SACCO, the government related Uganda Development Bank also conduct initiatives such as group loan for agriculture purpose. However, our interviews found that Uganda Development Bank extends an equally limited amount of medium-and long-term loan as regulated financial institutions.

4) Agricultural Funds Borrowing and Access to Financial Institutions

(1) Funds Borrowing

Let's take a look at the status of agricultural funds borrowing by farmers by analyzing Uganda Census of Agriculture 2008/2009. Please note that the survey period is somewhat old. At the time of the survey, the percentage of farmers who borrowed agriculture funds from financial institutions in the last five years was 10% of the total farm households. 76.0% of the borrowers answered that they were required to provide collateral or guarantor. The collateral details in order of high percentage are land rights (29.1%), guarantor (23.1%), crops (19.0%) and livestock (16.7%).

On the other hand, farmer households who had no borrowings accounted for 90% of the total number of farmer households. The number one reason for not borrowing agricultural funds is "high interest rates" (27.1%), followed by "lack of collateral" (20.9%). Many cases require land as the collateral, but more than 90% of the total land in Uganda is not registered formally, so we can say that land is not functioning fully as collateral.

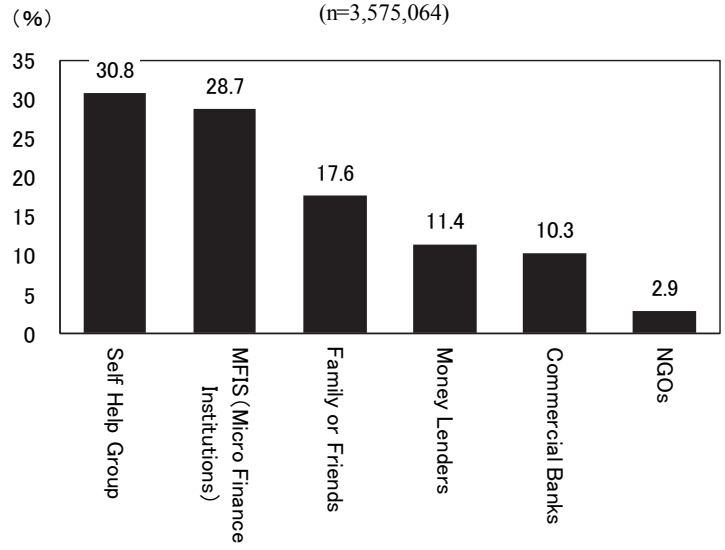
Furthermore, we asked the farmers who borrowed in the past about the lenders. The most answer is self help group (30.8%), followed by micro finance institutions (MFIS) (28.7%), and family and friends (17.6%) (figure 2-2). Non-regulated financial institutions,

[9] See Agricultural Finance Yearbook 2011 pp. 155–175 for details.

[10] See Agricultural Finance Yearbook 2011 pp. 14–17 for details.

such as VSLA, are included in self-help group. If we take a look at the presence of SACCO in rural areas, SACCO is considered as included in the choice, and falls under MFIS. In other words, when farmers borrow fund, they tend to use semi-regulated financial institutions and non-regulated financial institutions, while the percentage of borrowings from commercial banks (regulated financial institutions) is merely 10.3%.

Figure 2-2 The Farmers' Agricultural Credit Status From Financial Institutions and the Lenders in the Past Five Years (n=3,575,064)



Source: Uganda Census of Agriculture 2008/2009

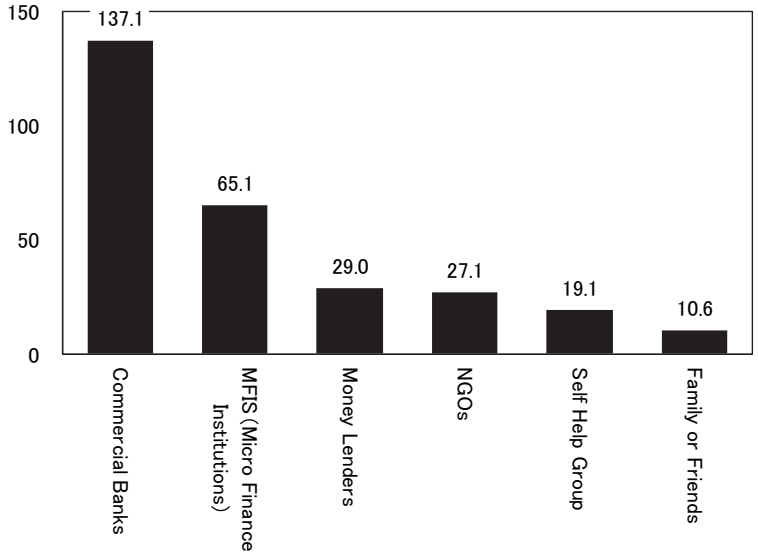
The details on redemption period of loans from commercial banks and MFIS are as follows: loans with less than one year period accounted for the biggest percentage (57.9% and 57.8%), followed by period of one to three years or less (35.9% and 36.2%), and period of more than three years is 6.1% each. We can see that half of the borrowers from commercial banks and MFIS borrowed short-term funding, while the number of those who borrowed long-term funding with period of 3 years or more is fairly low.

The average borrowing loan varies greatly according to financial institutions. The biggest amount is loan from a commercial bank (1,371,000 USH), or more than twice of MFIS (Figure 2-3). Considering that the average annual income of rural areas in Uganda is 1.7 million USH in 2006[11], we can see that those who borrowed from commercial banks are mostly large-scale farmers, not small and micro farmers. The number one use of borrowing from commercial banks is agricultural products sales (30.5%), followed by

[11] See JAICAF (2010, Japanese) p. 55 for details.

wages (25.7%), livestock (10.8%) and agricultural machinery (4.3%).

Figure 2-3: Average Amount of Loan
from Financial Institutions and the lenders



Source: Uganda Census of Agriculture 2008/2009

However, if we estimated the total amount of loan from all financial institutions based on the average loan from all financial institutions and the number of borrowers, the percentage of MFIS of the total loan amount is 41.4%, well ahead the commercial banks (31.7%).

With all these factors, those who borrowed from commercial banks are mostly farmers with large management (whose number is relatively small), and the fund use is mostly for sales, rather for production. On the other hand, we can see that MFIS, including SACCO, deals with relatively small funding requirement with most of its borrowers are small and micro farmers, who account for a large number of farmers.

(2) Access to Financial Institutions in Rural Areas

The data on access to financial institutions in rural areas can be found in a survey by Bill & Melinda Gates Foundation, which investigated the number of people who lived in 5 km distance from bank branches and SACCO in rural areas. According to the results of this study, the population ratio where a bank branch exists within 5 km distance is 8.4%, while SACCO is high, 37.3%. As shown in Table 2-1, the comparison between the number of regulated financial institutions and branches indicates a high number of

SACCO and SACCO is a financial institution that is relatively easy to be accessed by people who live in rural areas[12].

We can see from the above that the Government of Uganda has been implementing agricultural credit support through commercial banks and SACCO. Commercial banks mostly lend to large-scale farmers, such as commercial farmers, and SACCO plays an important role in providing agricultural credit to small and micro farmers, who made up the majority of farmers in Uganda. We would like to introduce how SACCO extends loans by presenting the results of interview with SACCO in the section below.

5) The Present Situation of SACCO as Suggested by the Results of Interview

(1) Overview of SACCO

First, let's have a look at the number of members of all SACCOs in Uganda. The total number of SACCO as of December 2012 was 2,112 with total number of members 1,154,000 people (individuals and groups) (Table 2-2). However, since a SACCO is not necessarily established by farmers, it should be noted that non-farmers may be included in the above data.

Table 2-2 Changes in the Number of SACCO Members

	June 2008	December 2012	Growth rate from 2008 to 2012 (%)
Number of SACCO	1,513	2,112	39.6
Number of members	644,318	1,154,625	79.2
Capital (million USH)	21,538	59,425	175.9
Deposit balance (million USH)	65,394	205,873	214.8

Reference: Number of Members per SACCO, etc.

Number of members	425.9	546.7	28.4
Capital (million USH)	14.2	28.1	97.7
Deposit balance (million USH)	43.2	97.5	125.5

Data: Ministry of Finance,Planning and Economic Development 2012, Evaluation Study of the Rural Finacial Services Programme and the Uganda Cooperative Savings and Credit Union

Source: Uganda Cooperative Savings and Credit Union Limited (UCSCU) headquarters, 2012

If we compare data of 2008 and 2012, we can see that the number of SACCO increased, the amount of capital and deposit balance also increased, and especially, the rate of

[12] However, farmers have low level of saving and lack of capability to put a minimum deposit or pay the investment share to become a member of SACCO, which resulted in the large number of farmers that cannot use SACCO remains unchanged.

increase of deposit balance is particularly high. The number of members per one SACCO in 2012 is approximately 550. This number increased by nearly 30% from the number in 2008. We can see that the increase in capital and deposits, along with the increasing number of SACCO have contributed to the expansion of SACCO management scale.

(2) Organizational Structure of SACCO

Secondly, let's review the current situation of 16 SACCOs based on the field survey conducted from October 2012 to December 2013[13]. All of the surveyed SACCOs are those whose members are mainly farmers.

The age and scale of those SACCOs vary largely. There is one SACCO that was just established, while another was established more than 10 years ago. One SACCO has around 100 members, while other has more than 10,000 members. These are the contributing factors to the significant difference in management scale, such as deposit balance. Many SACCO employed more staff and consolidated their management systems in response to management scale expansion. Some SACCOs are operating in several districts and have several branches. Some of SACCOs were established with initiatives from farmer group's leaders because it was difficult for the farmers to get agricultural loans from a commercial bank.

SACCO received assistance from MSC, which provided capital funds and UCA, the national organizations of co-operatives. All SACCOs surveyed are using a uniform standard in balance sheet and income statement. However, it is a common practice for SACCO to manage their funds manually regardless of management scale. The office work increased due to management scale expansion. Among the SACCOs surveyed, some were assisted by UCA and have introduced the computerized management.

(3) SACCO Financial Arrangements

Financial arrangements by SACCO differ according to its management scale. A large SACCO with an advanced management does not borrow funds from MSC or other institutions; it provides financing from capital funds gathered from the members' deposits. On the other hand, some SACCOs face management issue of securing finance resources due to their inability to provide financing from members' deposits only. This case is in particular true for small SACCOs, which were young in age. Thus, many small SACCOs receive loans from MSC or assistance from support organizations. Furthermore,

[13] Besides interviews to four SACCO by the author, this includes survey results to 12 SACCO (unfinished manuscript) that were carried out by JICA Uganda Office in October 2012–December 2013.

based on an analysis done on the balance sheets of some SACCO, we found that most of the deposits are liquid deposits regardless of management scale, and that financing structure is biased toward short-term loans.

We also found a large SACCO experiencing fund surplus that has been extending low-interest loans to a nearby SACCO that has fund shortage. At present, fund flexibility occurs only among SACCOs, and there is an advantage for SACCO that has fund shortage since they can make financial arrangements with lower interest than borrowing rate from MSC.

(4) Actual Condition of SACCO Financing

Many SACCOs extend loans for individual farmers as well as farmers groups. In order to respond to the diverse financing needs in rural areas, various funds for purposes other than agricultural purpose were founded, such as commercial, motorbike, education and housing. The interest rate, loan limit, deferment period and redemption period have been prescribed for each fund. However, in response to the members' demand, many SACCOs regularly review their funds by, among other things, raising the loan limit.

A borrower has to incur interest as well as various fees associated with borrowing. We analyzed income statement of several SACCOs and estimated that the annual lending interest rate is 20% per year and fees associated with borrowing are less than 10% per annum. The loan limit for groups is set greater than individuals. Some SACCOs introduced a policy in which a member who borrows for the first time will get a small amount of loan, and if the member pays back without problems, the loan limit will be raised gradually.

We could not grasp the percentage of loans for agricultural purpose from the outstanding loans. However, according to our interviews, a SACCO answered that its outstanding loans are mostly for agricultural purpose. A lot of SACCOs set a redemption period of 1-2 years for agricultural loans with a deferment period of six months. There are quite a lot of demands for working capital to buy production materials by the members. The practice of extending loans by SACCO at the time of purchase, in which the loan repayment begins after harvest, is common. On the other hand, large amount loans for equipment fund, such as agricultural machinery, is quite limited.

This phenomenon was caused by the low demand by small and micro farmers to buy agricultural machinery by loan and the low supply of lending by SACCO. The latter is due to reasons that have been laid out previously, i.e. most of deposits in SACCO are liquid deposits and loans from MSC are mostly short-term loans. Therefore, even if there are needs for medium-to long-term capital, extending loans is difficult.

(5) Credit Protection and A Characteristic Approach to Credit Risk Mitigation

Some of the SACCOs surveyed have introduced a system of personal guarantee for group loans, and did not require collateral. However, in principle a SACCO secures physical collateral (land, livestock, household furniture, etc.) and personal guarantee. A collateral in which the value of asset is several times the amount borrowed is often the case, whereas personal guarantee requires more than one guarantor.

Other than this kind of credit protection, many SACCOs conduct various efforts to mitigate credit risk. In order to prevent the borrower to divert funds for purposes other than the initial purpose, sometimes a SACCO staff would accompany the borrower to buy the necessary tool or machine and make the payment directly to the store, in the case of loans for production material. Other approaches included a requirement where a borrower shall deposit a percentage of the loan, and having members form a group, in which any loan application shall require all members' approval.

A large-scale SACCO that has stayed in the business long enough and made progress in management purchased a tractor and has been conducting the land cultivation for a fee, in response to the request from its members. This SACCO only deals with short-term working capital for agricultural loans. It does not leave equipment investment (to purchase agricultural machinery, etc.) to farmers or farmer groups, but instead, SACCO does the investment. This effort is seen as a way to mitigate credit risk.

Another SACCO is seeking to cooperate with Area Cooperative Enterprise/ACE[14], a farmers' organization, to efficiently run agricultural products marketing. SACCO cooperates with ACE through Rural Producer Organizations (RPO), a farmers group under ACE. ACE would conduct production material purchase necessary for farmers and agriculture products sales jointly, and SACCO would extend loans to farmers who are members of ACE. Some ACEs purchased agricultural machinery and conduct land cultivation services to their members. As the cooperation between ACE and SACCO progressed, farmers' income may increase through selling their agricultural products efficiently. ACE understands the farmers' operations, and it is believed that by sharing the farmers' information, SACCO can mitigate its credit risk and extend loans smoothly. However, while this kind of move seeking cooperation is being done, in reality, no specific cooperation has been reached yet. Many ACEs have vulnerable business infrastructure and lack financial ability to build a warehouse. Thus, the expansion of warehouse facilities needed for joint marketing of agriculture products is insufficient. Since farmers

[14] ACE is a farmers' organization registered with Ministry of Trade, Industry and Cooperative (MoTIC).

have a strong consciousness to sell agriculture products when they need living expenses, joint selling through ACE is not popular. In the future, to pursue cooperation between SACCO and ACE, improvement of collecting capability through the development of warehouse facilities along with profitable sale through strengthening selling capacity will be needed.

6) Conclusion

(1) Current Condition

Based on the result of analysis conducted until this stage, the current status of agricultural financing in Uganda can be summarized as follows. The main targets of agricultural financial support in Uganda are commercial banks and SACCO. Agricultural loans by commercial banks show an upward trend, and are extended mainly to large-scale commercial farmers who use the funds for processing and marketing, not agricultural production.

On the other hand, because the number of SACCO has increased, it has been expanding its business scale, and has better access than commercial banks; SACCO plays an important role in providing agricultural financing to small and micro farmers in rural areas. According to the interviews, although SACCO deals with a wide range of credit demands including the agriculture one, its agricultural financing are mostly the short-term ones used for purchasing production materials, and loans for agricultural equipment, such as agricultural machinery, are considerably small. Behind this no long-term loans is similar with that of commercial banks, i.e. having high risk of agricultural credit, and most of the financing is short term one. SACCO's credit protection is basically securing physical-collateral and personal guarantees. In addition, SACCO conducts various efforts to mitigate credit risk.

(2) Future Challenges

We can see from the above that to develop small scale and micro farmers in Uganda in the future, it is important for SACCO to provide a stable financing for those credit demands. Based on the current condition, it is considered that SACCO faces the following challenges to develop management further in the future.

Firstly, financial regulations and depositor protection system for SACCO have been established, and studies in Uganda have already begun. However, if SACCO is regulated in a similar manner to that of regulated financial institutions, depositors will be able to entrust their money in deposits comfortably, but on the other hand, SACCO is required to cope with the regulations. If that happens, there is a possibility that conditions will

be difficult for establishment of SACCO, and that SACCO will transform into a financial institution that is no longer affordable to small and micro farmers. In the light of these advantages and disadvantages, studies are being conducted in Uganda. How the regulations will be introduced will affect SACCO greatly.

Secondly, as small and micro farmers are aiming for management development, the need for borrowing equipment fund (such as agricultural machinery) will arise; and how to respond to this need is a problem. Since some SACCO and ACE are conducting land cultivation services using agricultural machinery, it would appear that there is a need among small and micro farmers to use machinery. However, as indicated earlier, financing arrangements by financial institutions (both SACCO and commercial banks) are extremely biased to short-term loans. If borrowing needs by farmers shall occur, financial institutions are in a difficult environment to extend medium-and long-term loans. To overcome this situation, the Government of Uganda has provided a system where medium-and long-term loans can be extended through ACF and MCS. In spite of this, there are almost no medium-and long-term loans to purchase agricultural machinery.

In addition to the problem of mismatch between financial institutions' financial arrangements and fund management, a detailed investigation on the impediments to medium-and long-term loans may be necessary. Financing might be prevented if the need to borrow by farmers to purchase agricultural machinery does occur, but instability in farm management due to factors such as weather and the fact that land cannot function as collateral due to the lack of land registration practice. In this case, a more extensive infrastructure development is deemed necessary, such as expansion of crop insurance system and improvement of land registration system.

These problems cannot be solved only by SACCO; a systemic change throughout the country is needed. SACCO has been taking measures to stabilize the farm management and provide stable funding by seeking cooperation with ACE, which conducts joint selling of agricultural products. If co-operative members can jointly purchase production material needed at a low cost and sell agricultural products efficiently, their income increases and capability to repay loans from SACCO will be improved as well. If SACCO can comprehend the flow of household economy of its members through collaboration with ACE, the loan review process can be done without any difficulty. The directions that are being sought by SACCO is deemed reasonable, since the mechanism of supporting the farmers' management development through the comprehensive sales business and financial business can be found also in general agricultural co-operatives in Japan. At present, the cooperation between both parties are not adequate because the business of

ACE is still insufficient. It is necessary for the government to create mechanism to continue supporting these developments.

Currently, there are moves to form agricultural financial institution in Uganda. It is necessary for the agricultural financial institution to carry out countermeasures aimed at improving the lack of medium-and long-term loans, the condition that prevails so far. In addition, the support activities by ACE and SACCO as described above will become an issue. More notice needs to be taken of how the newly established agricultural financial institution plays its role and function.

In Uganda, besides the government assistance, support in the agricultural sector is extended by various support organizations in abroad. Some of the farmers we surveyed received support from overseas support groups and purchased agricultural machinery. If farmers hold great expectation for external support, there is a possibility of a lower incentive for the farmers to borrow funds to purchase agricultural machinery in order to improve their productivity and to repay the debt from the revenue gained. On the other hand, as introduced earlier, some SACCOs have been offering land cultivation service as a result of self-sustaining management development. It is crucially important that any support related to agricultural financing shall be carried out within the framework of promoting the self-sustaining development of farmers and SACCO.

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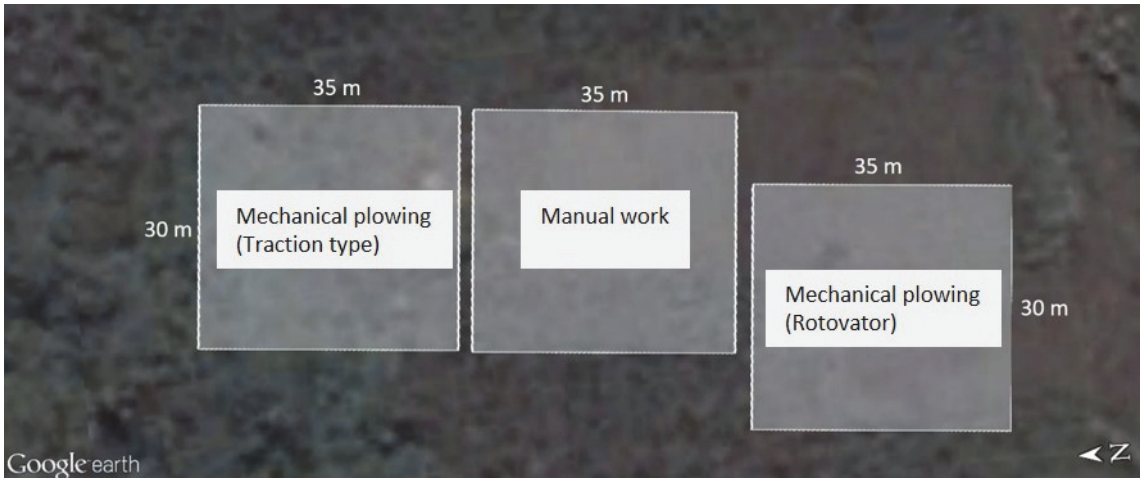
Chapter 3 Feasibility Experiment Results

1. Field tests in NaCCRI

1) Test Method

Within the NaCCRI seed production field, a total of three sections of 30m x 35m (10.5 a) were made: two mechanical plowing sections (section 1, using rotovator type, and section 2, using traction type) and (3) plowed manually (Figure 3-1). Mechanical power tiller introduction experience is scarce and no mechanized system has been established in Uganda. From the fact that within the JICA Rice Promotion Project and AEATREC we had two types of power tillers manufactured in Japan, a moldboard plow and a disk-connected traction type, two mechanical plowing wards were prepared. Within each section, we investigated mainly labor productivity by using power tillers, harvesters, threshing machines, winnowers, according to each of the periods of rice cultivation: plowing, intertillage (weeding) and harvesting. We used NERICA4 rice type.

Figure 3-1 Farming Experiment Field Experimental Section Layout



Note: Since the soil on the east side of the mechanized (rotovator) section was harder than that of the other two wards, we shifted the ward 10-meter westwards in order to match soil conditions.

<1> Plowing Experiment

Plowing test was performed from August 25 to September 7. Within the NaCRRI field we extracted a region of comparatively uniform soil condition after investigating 1 ha of test candidate field, and then set two mechanical labor sections and one manual labor section. Within the mechanical plowing section 1 (rotovator), we performed one moldboard plowing, then plowed by rotovator type. Within the mechanical plowing section 2 (using traction type) we performed one moldboard plowing, then one plowing

by disk plow. Within the manual plowing section 3 we performed two plowings by using hoes. As clod breaking was still rough after the plowing work in fields 2 and 3, in order to obtain a soil breaking level similar to rotovator work in view to seeding within the rain-fed lowland conditions, we performed manual soil breaking after the plowing. We measured working time and fuel consumption within the plowing work and compared the labor productivity of each section.

<2> Weeding Experiment

Weeding test was performed from October 23 to November 12 in each of the sections 1 to 3, after the plowing test. Within the mechanical work, we performed weeding by attaching a weeder as a work machine to the traction-type power tiller. Within the manual work section, the same operation was performed using hoes. The weeder's mechanism consists of two triangular blades (spades) disposed to the left and to the right, so that it works on two crop lines from three within the rice field. When turning, the machine is shifted laterally by one line, so that weeding can be performed through all the in-between space of the rice fields.

We measured working time and fuel consumption for the weeding test. Due to the characteristics of the weeder, the measured time is the time needed for weeding the in-between lines (furrows). As for the spaces between plants, we decided to perform weeding according to needs.

At the time of the weeding test (50 days after seeding), mechanical work section 1 (rotovator) was in the best conditions of clod-breaking, uniformity and growth.

<3> Harvesting Test

Harvesting test was performed from January 16 to February 11, 2014. Within the mechanical work sections, we used a harvester made in Japan, a throw-in type threshing machine made in China and a motorized winnower. A similar work was performed manually within the manual work section. We measured work times in a similar manner to the tests above. As within this threshing experiment we used a throw-in type threshing machine, reaping was performed slightly upper, and not by the root.

2) Test Results

<1> Plowing Experiment

Total work time needed for mechanical section 1 (rotovator) was 210 minutes, for mechanical section 2 (traction type) 90 minutes were needed for moldboard and disk plow work. Total time needed for section 3 (manual work) was approximately 127 hours for

the primary work (Table 3-1). Farming work per 1ha can be calculated as 35 hours for section 1, 15 hours for section 2, and around 1270 hours for section 3. Therefore we appreciate that plowing mechanization by plowing machines can contribute to cropland area extension even for small-scale farms.

Concerning soil conditions after the plowing work, section 1 (rotovator) had the finest clod breaking and uniformity. In order to obtain similar clod breaking conditions in order to perform seeding on section 2, manual clod breaking took approximately 87 hours. Within this study after consultations with AEATREC, when considering a scheme of rice cultivation mechanization by traction-type machines, we adopted the plan to perform manual clot breaking after moldboard plowing and then disk-plow work, but by the farming survey during the present project, we consider that test result time could be reduced, as we found out a method to apply the moldboard plow for several times.

Fuel consumption of the power tiller was 2.59 liter on section 1 and 1.30 liters on section 2. Fuel consumption can then be converted as to approximately 26 liters and respectively 13 liters per hectare, amounting to 2000 to 4000 JPY fuel cost per hectare. Manpower at the actual place is supplied by hired people, insufficient during farming periods (5 hours / day, 6000USH, about 240 yen). Supposing that the entire work is performed manually, 0.1ha costs would amount to about 60,000 yen and 1ha would require about 600,000 yen. Even by hiring laborers only partially in order to complete farm work within the adequate periods cost are very high for small-scale farmers, so that the mechanization of plowing work would be more economical in case of cropland extension.

Table 3-1 Labor Time and Fuel Consumption within Plowing Test

Test section	Total quantity of work (Labor hours and minutes of work as done by one person)	Fuel consumption (liters)
Mechanized Work Section 1 (rotovator)	3 hours 30 min	2.59
Mechanized Work Section 2 (traction type)	88 hours 54 min	-
of which machine work is	1 hour 30 min	1.3
of which manual clod breaking	87 hours 24 min	-
Manual Work Section 3	126 hours	-

<2> Weeding Experiment

This operation needed 1 hour in each of mechanized sections: 1 (rotovator) and section 2 (traction type). Within section 3 (manual work) the operation took 46 hours (Table 3-2).

Operation time per 1 ha would be 10 hours in the mechanized sections and 460 hours in the manual work section. Actually, due to the fact that spaces between plants also need a reasonable weeding, the real efficiency is not as high as it is shown by the results. However, rain-fed lowland rice-field needs three weeding operations for each cultivation work, therefore mechanization is expected to greatly reduce farmer's labor load.

Table 3-2 Weeding Experiment Results

	Quantity of work (mechanized)	Quantity of work (manual)	Mechanized section efficiency index (vs. manual work as 1)
Mechanized Work Section 1 (rotovator)	59 min.		46.8 times
Mechanized Work Section 2 (traction type)	1 hour 5 min		1
Manual Work Section 3		46 hours	42.5 times

According to the farming survey performed in Nankoma, Bugiri District, mechanization is strongly expected, as weeding labor is especially burdensome compared to other activities. By the present experiment, we understood that mechanization would greatly increase weeding work efficiency. Nevertheless, we also found out that weeding labor needs the following conditions to be respected, compared to plowing. As these conditions are believed to be faced upon the actual mechanization performed by the farmers, we would like to organize these problems for on-site use.

(1) Weeding Labor Start Timing Issue

In order to use the weeder, the operation should be started when weeds are smaller than the rice plants, so that the operator can discriminate them visually. Since we were not able to match weeding timing for a part of the present experiment, we performed a preparatory weeding in order to allow visual observation. This issue needs to be taken into account adequately also in case of extension of arable area by mechanization.

Since the power tiller extends on three lines and passes over the center line, the time of the third weeding should be chosen so that weed height is so that the rice plants are not damaged. For the present experiment we considered that weeding before the basal dressing done 21 days after seeding and before the top dressing done 54 days after

seeding would be efficient, but optimal periods should be sought for according to plant type, by accumulating experience for several times.

(2) The Relationship between line width and power tiller wheel width

Concerning rain-fed lowland cultivation including NERICA, in Uganda we have recommended 30-cm line width as a standard. Seeding within this experiment was also performed upon this standard. Basically, power tiller's tires must pass through the inside or outside of the inter-row space. With regard to this point, the wheel distance of the power tiller used for this experiment (the thread distance between the centers of left and right wheel) was of 67 cm. Since wheel width was 12 cm, the machine treaded on the rice line.

As for AEATREC, we consider that one treading over a plant does not pose any problems concerning plant growth, but as long as weeding must be performed for 2 or 3 times, impact upon plant is considered to be unavoidable. Although the power tiller used for the present experiment is of an un-adjustable type we have no choice but to continue weeding work using it. Nevertheless, upon the introduction of power tillers, consideration should be done about the possibility to adjust wheel-distance and about the possibility to select slim steel wheels. Inter-row distance adjustment can also be considered upon mechanization. In case of a supposed 40-cm width, although this would lead to a lower areal productivity, when considering that mechanization would allow the extension of the cultivated area up to several times, farmers could still increase their income.

(3) Assuring power tiller turning area

We discovered that a buffer zone outside of the rice-field is necessary for turning the machine, as the weeder is connected to the rear of the power tiller as a working part.

This issue must be taken into account upon mechanization also in order not to damage neighboring farm fields.

<3> Harvesting Test

Although operating time was reduced by mechanization for each of the operations of harvesting, threshing and winnowing (Table 3-3), the efficiency improvement due to mechanical harvesting was especially remarkable, as mechanical operation time was approximately 30 minutes, compared to 15 hours needed for manual work (labor time per 1 ha is 150 hours for manual work and 5 hours for mechanical work).

During the present experiment, the harvester became very famous, as many of the farmers who attended the test said that the next product they would buy after a power

tiller would be a harvester. On the other hand we observed challenges as: (1) machine turning cannot be done in an optimal manner and requests a long time in case of low handling proficiency, (2) As work extends in time, labor becomes difficult as it is harder and harder to concentrate, so that 1st gear must be used instead of the 2nd gear, (3) Bearing in mind the on-site management level, since the harvester is made of finer parts compared to power tiller, part dropping may occur during work.

Within the threshing experiment, the results were of 187 hours of manual work and of 50 hours of mechanical work calculated per 1 hectare. Concerning manual work we chose the method used to beat the rice-ears by bars, which is performed locally, but this method provoked many losses due to the dispersion of a lot of rice grain, even though we tried to collect it by extending a plastic sheet over the work field. Moreover, since improved rice types are difficult to thresh, the actual efficiency of mechanization is believed to be even better than pointed by the results.

Within the winnowing experiment, labor was performed over 10 kg of rice. By considering a harvested quantity of 2 t per 1 hectare, manual operation requires around 27 hours, while mechanical operation requires around 3 hours. Within the practical manual winnowing operation:

(1) Man-hour per one time is scarce and not fit for larger harvested quantities;

(2) Efficiency is influenced by wind speed;

(3) Impurity removal is difficult to perform by one operation;

(4) Dispersed grain gathering takes even more time.

On the other hand, mechanized labor allows almost complete impurity removal by one operation and it is believed to be even more efficient than pointed by the results, similar with threshing.

Table 3-3 Labor Time and Fuel Consumption within Harvesting Test

Operation Contents	Manual Operation Time (hours: mins)	Mechanical Operation Time (hours: mins)	Mechanized section efficiency index (vs. manual work as 1)
Harvesting	14:50	0:27	33 times
Threshing	18:40	4:05	4.6 times
Winnowing	2:54	0:24	7.2 times

Note: With regard to harvesting and threshing, harvested product of a 0.1 hectare field was considered. Hence, we processed 10 kg of grain within winnowing, but we calculated the operation time considering 2 ton/ha, or 200 kg/0.1 ha.

2. Farming Experiment around NaCRRI

1) Test Method

(1) Plowing, Weeding and Harvesting Experiment

We performed the empirical test on farm fields of Seetabaale village, Busukuma, in Wakiso District. Basically we measured operation time and fuel consumption in order to evaluate labor productivity on mechanical labor fields and manual labor fields, in a similar manner with that used during the test within NaCRRI. As for changes, we used only traction-type power tillers as machines, and also we set 10 mechanical labor sections and 10 manual labor sections.

The test fields were taken on lease from farmers living around NaCRRI. We requested the farmers using the fields and AEATREC for the labor needed for the test.

(2) Rice-milling Experiment

We performed a rice milling test from February 8 to 12, using the rice grains obtained by implementing the above experiment. Rice-milling of rice produced in Uganda is not performed manually, but using rice mills. As for the present experiment we considered the rice milling by Engelberg-type rice mill (made in China) -- which has been used for a long time-- as a traditional technique, and we compared its performance with the Mill-top-type rice mill (copy made in China of a Japanese machine) -- appreciated as of good performance in the western part of Hoima District where it was wide spread -- as the improved technique.

As survey results indicated that rice milling is performed by passing grains twice through the machine, as rice milled by the Engelberg-type presents unpolished rice grains, we performed rice milling by the Engelberg-type for two times. As the test was performed at AEATREC, we attempted a comparison of energy costs by measuring the energy consumption of the facility. Upon rice milling, after performing stone removal using a stone removing machine made in Japan, we performed a comparison of the crushed grain ratio by passing the grains through a grader (rotary shifter) made in China.

2) Test Results

(1) Test Results from Plowing to Harvesting

Operation times for plowing (twice), seeding, weeding (intertillage), harvesting, threshing up to winnowing by mechanized work and by manual work are presented in Table 3-4. Within 1 hectare of rain-fed lowland rice field, labor productivity improved by 25 times due to mechanization.

Table 3-4 Operation Times for Mechanized Work and Manual Work

Operation Contents	Mechanical Operation Section	Manual Work Section (Calculated as done by 1 person)	Index of Improvement Rate (setting amount of manual work as 1)
First plowing (mechanical: moldboard plow) (manual: hoe)	12 hours 15 min	213 hours 2 min	17.5
Second plowing (mechanical: disk plow and manual clod breaking) (manual: hoe and clod breaking)	10 hours 31 min	222 hours 2 min	21.1
Seeding (mechanical: 4-row seeder) (Manual: row seeding)	6 hours 50 min	268 hours 50 min	39.3
Weeding (intertillage) (mechanical: 2-row weeder) (manual: hoe)	7 hours 29 min	621 hours 4 min	82.9
Harvesting (mechanical: 4-row harvester) (Manual: machete)	3 hours 56 min	133 hours 46 min	34.4
Threshing (mechanical: throw-in type thresher) (manual: log hitting)	24 hours 40 min	182 hours	7.4
Winnowing (mechanical: motorized winnower) (manual: winnowing basket)	41 min.	3 hours 12 min	4.0
Total	66 hours 22 min	1643 hours 56 min	24.8

We calculated times per hectare from the average measured time within plots of 0.1ha in test sections.

Thresher operation requires at least 3 persons.

In fact, there is no mechanization system established locally. Moreover, as preparations and maintenance required for mechanical labor has not been taken into account, actual mechanization times shall be different. Seed adjusting of the seeder is especially difficult. Also there is a problem regarding mechanized weeders. It can cover inter-row spaces but spaces between plants needs to be done by manual work. On the other hand, grain loss such as spilling due to log lashing of the plants after harvesting, paddy left over due to manual threshing, or spilling when winnowing have been recognized as important, so that improvements done by mechanization are expected.

Since farming labor times often exceed 200 hours per hectare when done manually, due to the fact that long labor times are necessary even in case of performing them by hiring more staff when needed, operations cannot be completed by the adequate periods and also land extension seems to remain difficult.

On the other hand, fuel necessary for farming labor per 1 hectare was approximately 40 liters, which is around 150,000 Ush (6,000 JPY) (Table 3-5 and 3-6). Since harvests on the test performed on farmlands were of 2 tons of paddy (1,340 kg of milled rice) per 1 hectare both on mechanized and manual sites, by considering a price of 1,800 Ush/kg of milled rice, the income per 1 ha is expected to be of around 2.4 million Ush (96,000 JPY), therefore fuel price should not be a great burden. On the other hand, cost of staff add-up in order to complete the necessary work by manual operation are very high, therefore farming land extension is not possible for small-scale farmers under the current situation such as farming by manual work under family management.

Table 3-5 Fuel Cost for Mechanized Labor

Operation Contents	Mechanical Operation Fuel Consumption (liters)	Fuel Cost (Ush)	Fuel Cost (JPY)
First plowing	9.2	33,120	1,325
Second plowing	6.75	24,300	972
Seeding	3.38	12,168	487
Weeding (intertillage) (supposing 3 times)	2.59	9,324	373
Harvesting	12.45	44,820	1,793
Threshing	6.0	21,600	864
Winnowing	0.45	1,620	65
Total	40.82	146,952	5,878

Fuel price was considered as 3,600 Ush/liter (during present year project).

Table 3-6 Staff Salary for Manual Work

Operation Contents	Salary for manual work (Ush)	Salary (JPY)
First plowing	255,640	10,226
Second plowing	266,440	10,658
Seeding	322,600	12,940
Weeding (intertillage) (supposing 3 times)	745,280	29,811
Harvesting	481,560	19,262
Threshing	218,400	8,736
Winnowing	3,840	154
Total	2,293,760	91,750

Staff salary was considered as 6,000 Ush/ day, at 5-hour labor / day (during present year project).

(4) Rice-milling Experiment

As a result of the milling experiment, Mill-top-type miller provided an operation 4.4 times shorter than Engelberg-type miller. Engelberg-type miller has a longer operation time than the Mill-top-type miller even in case of single processing. Nevertheless, the Engelberg-type miller cannot actually provide completely milled rice from the first time and requires a second processing. Therefore more time and energy is required.

The Mill-top-type miller is proficient also in terms of energy consumption, as it saved more energy. In a similar manner with operation time, the Engelberg-type consumed more electricity than the Mill-top type even operating only one processing. Therefore, results showed the Mill-top type as more proficient in terms of energy consumption and also as providing a better labor productivity, in comparison with the Engelberg type.

Using a grain grader, we compared broken rice grain ratio of the rice milled by the two types above within the present project. Broken grain ratios presented no conspicuous difference. The Mill-top type presents the problem that technical skills are required in order to adjust gap of gum-roller as a preprocessing operation.

Table 3-7 Fuel Costs for Mechanical Work and Staff Salary for Manual Work

	Engelberg type	Mill-top type
Rice Milling Operation Time (1st time for Engelberg type)	31 min 44 sec.	11 min 12 sec.
Weight after processing	71.23 kg	70.91 kg
Power Consumption (2nd time for Engelberg type)	4.11 kWh	1.36 kWh
Rice Milling Operation Time (2nd time for Engelberg type)	17 min 17 sec.	-
Weight after processing	67.07kg	-
Weight after processing	1.48 kWh	-
Total Processing Time	49 min 1 sec.	11 min 12 sec.
Total Power Consumption	5.59 kWh	1.36 kWh

Results for both machines were calculated as for a quantity of 100 kg of paddy.

Upon the implementation of the present experiment, AEATREC, which performed human resource support such as agricultural mechanization technicians, operators, etc., recommended further demonstration tests in other rain-fed lowland rice-field regions situated in Uganda subsequently to the region of the present test. Moreover, AEATREC promised: (1) Demonstrations of farming machines including power tillers and

distribution of information aiming to efficiency improvement by media; (2) training aiming to skill improvement; (3) Technological support towards farmers, NGOs, government institutions interested in power tillers made by Japanese makers and relevant technology and active support concerning the supply of relevant information towards bilateral private sectors of Japan and Uganda.

3. Power tiller Introduction Test Follow-up Results by VECO

1) Background

In this project we approached the farmers of Nankoma in Bugiri District, who have received financial support for power tiller introductions as a part of the production improvement project of the Belgian NGO, VECO. VECO established priority on agricultural products for production increase and farming techniques for each of the subject lands in Nankoma in Bugiri District, Kameke in Pallisa District, Kisoko in Tororo District, Kibuku District and other areas. It has performed financial support for mechanization including (1) land development for harvest increase, (2) value-adding to agricultural products and (3) ox farming labor. Prioritized agricultural products are peanuts, corn and cassava for Nankoma, rice, cassava and peanuts for Kameke, peanuts, corn and onions for Kisoko and corn, cassava and beans for Kibuku District. Financial support targets includes ox farming, power tillers and 4-wheel tractor purchase. The financial support for power tiller purchasing was performed in Nankoma.

For case in Nankoma, VECO created a system by which they purchased and supplied to Nankoma ACE sets of power tillers and farming machines (moldboard plow, disk plow, trailer, cage wheels) amounting 20 million Ush (around 800,000 JPY) per set, then VECO supplied half of the purchasing sums to interested farmers who paid the other half amounting 10 million Ush (400,000 JPY). This scheme allows farmers who can pay 2 million Ush (around 80,000 JPY) to buy a power tiller, then to complete the payment of the rest of 8 million Ush in two years, by paying 2 million Ush each half year.

2) Follow-up Results

From 2012 to 2013, nine units of power tillers made in Japan were bought at Nankoma ACE. The verification test using power tillers described above permits the test of labor productivity for each of the farming works. Nevertheless examining base cost concerning durability, which is indispensable in order to verify mechanization, is difficult. On the other hand, information is very scarce with regard to the ways to improve farming management as a result of the direct possession of power tillers by farmers in Uganda -

- not limited to power tillers made in Japan -- so that these purchases become valuable examples.

During the present project, we visited six of these farmers and interviewed them concerning basic information such as income, cultivated areas, cultivated products, and also about power tiller durability and changes of farm management due to the introduction of power tillers. Locations of Nankoma ACE and of the farmers we visited are presented in Table 3-2. We were not able to investigate the farmers who purchased the other three power tillers due to reasons as not meeting their convenience or they were using the power tillers in other districts.

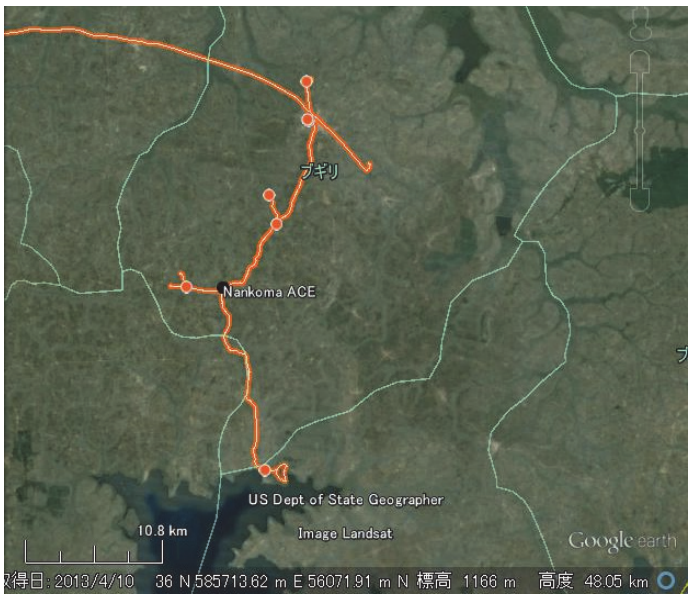


Figure 3-2 Locations of farmers possessing power tillers in Nankoma, Bugiri District

Farmers possessing power tillers who were subject of the investigation (red circles), Nankoma ACE office (black circle)

Source: Google Earth

(1) Farm management done by farmers who own power tillers

As we asked about changes after the introduction of power tillers, several farmers answered that they extended farming surfaces up to four times due to the improvement of labor productivity. They worked not only on their own farms, but also did alternate farming for surrounding farmers. We could observe an increase of farming surfaces in the area. Apart of alternate tilling, some people were gaining profit by using the power unit as motor for maize shellers (corn shedding machines). Power tillers can be also used for irrigations by connecting them to water pumps.

Price of alternate farming prices are set at 60,000–80,000 Ush per 1 acre (60,000 Ush are approx. 2,400 JPY, which is around 6,000 JPY per 1ha), they range cost of services using 4-wheel tractor (around 80,000 Ush = around 3,200 JPY, which is around 8,000 JPY per 1ha) and ox farming (40,000–50,000 Ush; 40,000 Ush are approx. 1,600 JPY, which is around 4,000 JPY per 1ha). Some people said that alternate farming is not well received due to its higher price compared to ox farming. Nevertheless, in this region where tilling or weeding are reported not to be done within the adequate periods due to lack of working force, power tillers are believed to be useful enough as they are faster than oxen.

Transport of quantities of more than 500 kg at a time is possible by joining a trailer to the power tiller. They say that locally they used to transport agricultural products (i.e. corn) to their homes or to the common barns by carrying them on their heads traditionally, or loading them on bicycles then pushing bicycles by hand, or by bike taxi (boda-boda), but due to the transport using the power tiller time and expenses reduced. There were also persons who increased their income by transporting not only agricultural products, but also bricks or other construction materials for a charge.

Power tillers were used also for transporting water for daily life use. According to one possessor, before the introduction of the power tiller, his family used to go to the water place for water 7 times each day using three or four cans of 20 liters, but now they go only 4 times a week as they carry water by the trailer. He said that due to this, women and children were spared of a hard work and now water supply for people and also for livestock can be done much smoother.

Farmers who used their power tillers skillfully were able to use most of the time that they saved by the improvement of the labor efficiency to other farming activities that were previously impossible. There were persons who spent a part of their time for union activities.

(2) Power tiller Durability

During this project, we visited Nankoma four times between July 2013 and January 2014. During our investigations, there were no power tiller failures concerning engine, gearbox or main parts. On the other hand, failures of smaller parts, especially acceleration lever or clutch lever were often reported. The most often reported failure was damage of the trailer joint part (tow rod). Moldboard plow and disk plow welding ruptures were also observed. Apart these failures, bending of rear-wheels or of the brackets mounted to the main body hitches, by which mounting was disabled, were also observed.

Failure causes are considered to be inappropriate handling by operators and trailer overload, but region-specific causes could also be considered. The reason for selecting power tillers manufactured in Japan for application in Nankoma was their failure robustness and their high reliability compared to cheaper machines made in other countries. Nevertheless, these machines are conceived and sold having in mind Asian paddy rice. Therefore, causes of the failure of various parts that could not endure: (1) handling done by local people, who are of large physique and strong, (2) very uneven dirt farming roads, (3) Ugandan soil, especially hard and sticky soil of rain-fed lowland and maize farms could be also considered.

From owner's point of view, the unavailability of the power tiller due to the damage of the acceleration lever of clutch lever, which, although minor, are parts of the main body, is not much different from other failures, and may lower the level of reliability of the power tiller itself. On the other hand, often failures of the plows imported at the same time-- although they are not the main body--, also cause great inconveniences, so that as provided these plows are recommended by makers, they need thorough consideration of local soil conditions and usage.

With regard to consumables, such as transmission V-belts, gum tires (dirt tires), lubrication oil, etc., wearing of V-belts and gum tires was severe. Investigations pointed to improper assembling and adjustment of V-belts, which could be a cause of their wearing. On the other hand, since there were people who claimed failures on the next day after replacement, it seems that product quality at the time of purchase and deterioration due to long-term storage is also a problem.

As for gum tires, wearing was more and more severe at each further investigation; we saw two cases of ordinary vehicle tires equipped to power tillers due to usage failure. This kind of tires was used because of the difficulty of procuring power tiller-dedicated tires. Nevertheless, the machine is deprived of most of its performances, since such tires equipped to power tillers cannot adhere to surface to ensure sufficient thrust force. With regard to this point, we investigated even large-scale tire stores in capital Kampala, but could not obtain a clear response whether this kind of tires is available or not. Chinese-made power tiller retailers responded that they have tires in stocks, but these tires do not fit the power tillers manufactured in Japan that are used in Nankoma.

Together with gum tires, the lack of spare parts, i.e. clutch levers, is also a problem. Farmers are replacing them by motorbike parts, or try aggressive repairs or corrections by blacksmiths. Basically, the dealers who sold the machines should also supply parts, but the reality seems to be that, as long as the farmers cannot contact these dealers or part retailers in larger cities, they do not know how to order parts.

(3) Daily Maintenance Management

Five of the farmers who own power tillers have already received training about usage and maintenance from AEATREC, but there is still room for improvement of maintenance concerning most of the farmers. Concerning V-belts, there were cases of peoples who displaced the whole engine in order to adjust the V-belt, as they did not know how to tension the V-belt when replacing it. There were also cases of people who lost engine-mounting bolts and were running their machines in a dangerous manner, by only 3 bolts instead of 4. With regard to oil change, there were cases of people who did not know the appropriate quantity of gear oil, so that they put too much oil and thus caused oil leakages.

Most of the failures are minor, but there are quite many cases of users who suffer failures or wearing due to the lack of understanding of the proper maintenance method, which could follow into more critical failures. From this point of view, we considered that further maintenance and management guidance is necessary. There were also cases when the people who were requested to repair power tillers or work machines tampered with them without understanding basic structures and failed. Therefore mechanics also need urgent guidance.

As we were quite concerned of this situation, more than doing training for power tiller owners about usage and management methods, we also executed training for repairmen and mechanics in the surrounding regions.

(4) Ownership

It seems that owners in this region use to hire operators in order to perform farming activities. Also for the case of Nankoma, each power tiller owner hired a couple of operators, apart the owner himself. There were only two cases of management performed by the owner, in all the other cases machine running and management being performed by operators. There were also cases when owners just handed power tillers to neighboring farmers and only receive fees.

Under such a situation, operators can perform alternate farming on their own by cheating about payment and fuel prices without any advice from owners. In fact, we found such reports. Apart considering the effects of such use to the quality of plowing work, the loss of confidence towards the power tiller itself was a point of concern, as machine life cycle shortens due to the lack of responsibility concerning maintenance and management.

(5) Power tiller Payment Situation

With regard to payment, there were two cases of farmers who confirmed to be able to pay purchasing expenses within two years. As they are also using power tillers as power sources or as transport vehicles and also lend them for a charge, we conjectured that mechanization enables capital refunding sufficiently.

On the other hand, there were responses that payment is difficult due to the drought during the first half of 2013. Although drought effects are unclear, drought seems to be one of the causes of the delay of the payment. Nankoma ACE detains some traces of registrations of activities made at the beginning of the purchases, but at present management done by operators does not seem adequate, as such registrations have been interrupted. There is a chance to promote adequate usage and also prevent payment delays by ensuring a thorough activity registration input.

Citation and Reference

1) Tsuboi, Tatsushi, Rice Cultivation Handbook, Promotion of Rice Development (PRiDe) Project

Chapter 4 Development of Agricultural Business and its Challenges

1. Challenges for farmers

We believe that income increase for small-sized farms can be achieved by the following changes, among others: enlarging cultivation area and optimum seeding period area; boosting unit crop yield through cultivation method enhancements; raising product value by planned adjustments of shipping periods and processing, among other measures; and sales in the markets with better pricing and terms. In all of the above, mechanization is possible.

1) Mechanization of ploughing

We understand that farmers wish to mechanize, of all the mechanizable operations, plowing – the heaviest agricultural work. It is estimated that the maximum manual labor capacity of plowing for a family-sized farm is around 1 ha. In fact, our interviews across Africa show that farmers usually have 3 to 4 times larger farm lands compared to the size of land they actually use, and as a result, not all the arable lands are being utilized. It should be noted that some of these lands are used in livestock raising and orchards, but we noticed that in general a large part of those remain unused as the farmers' manual plowing capacity is limited.

On the other hand, farmers who introduced tractors there have successfully increased the size of cultivated areas by 3 to 5 times, and they have succeeded in optimizing farmland use. In addition, many of the farmers who purchased tractors are motivated to further increase their farmlands by leasing and purchase, in consideration of their mechanized capacity.

2) Improvement of ploughing

Raising the speed of farm field plowing enables seeding of these fields at the optimum periods. When farmers introduce seed planting attachments to tractors, they become able to seed with much more room for maneuvering. This in turn will allow them to improve sprouting and growth of their seeds. Furthermore, their mobility can be further boosted by combining the above with timely weeding with hoeing machines, and by attaching irrigation pumps to tractors, so that the farmers can irrigate and water only the areas that need them, to help the growth of plants. The crops that the farmers raise to feed themselves now can be harvested in excess, and the excess can be marketed in markets as cash crops. This in turn will allow the farmers to enjoy a direct increase in their income. We also observed that some farmers lease their tractors as the powering source for maze shellers and milling machines, to further boost their income. It should be noted that their lease businesses are making contributions in improving the labor efficiency of neighboring farms.

3) Machine hiring service/human labour and their distribution

The farming families that introduced tractors have succeeded in increasing their income by plowing farm fields of neighboring farms for fee, while at the same time being engaged in a variety of hired farm operations that utilize the mobility of their tractors. The neighboring farms enjoy the benefit of the mechanization, specifically by enlarging the size of cultivated areas, while becoming able to farm more efficiently.

When the yield increases in an area, a growing center is developed there, in the form of joint shipment and other means. This in turn will enable farmers to win an advantageous position when negotiating with buyers.

4) Value addition

It should be noted that a temporary price collapse could occur as the yield increases. On the other hand, it also becomes possible for farmers to market their crops by promoting value-added features, for example by setting up joint processing facilities, by grading crops and adjusting shipment periods through the establishment of storage facilities, among others.

5) For purchasing agricultural machinery

Under the current government policy of Uganda, the importance of mechanization is stressed. However, at the same time, the government subsidy to farmers' machine purchase is close to non-existent. What is more, the existing financing system makes it difficult for ordinary farmers to get an approval for their financing requests. In fact, regrettably, most of the tractor introductions in the past involve some kind of foreign assistance. In this kind of circumstance, it would be a realistic choice for farmers to form co-ops and other organizations to jointly purchase farming machines. With regards to farmer organization, plans have been made by international organizations, aid agencies of various countries, and non-governmental organizations (NGOs), and the plans are proactively implemented by these organizations within their frameworks.

2. Challenges for Ugandan companies

1) Distributors

Most of agricultural machine distributors are operated by Indian or Chinese trading companies and shops. Major Indian distributors market 80-horsepower-plus tractors made by Massey Ferguson. But they are not necessarily manufactured in the United Kingdom; many of them are made in India, Pakistan, and Brazil. Each distributor claim that what they market is more authentic than others. What complicates the matter is the marketing of pre-owned Massey Ferguson tractors. In addition, what would be considered as large-sized tractors in Japan, manufactured by John Deere, New Holland, as well as India's Mahindra and Sonalika, are marketed for large-sized farm companies. Among these

competitors, only a small number of Japanese farm machines are sold in Uganda. On the other hand, the Ugandans' general trust toward Japanese products, grown largely through their use of Japanese automobiles and home electronics products, is deep, and for that reason, several distributors noted that they wanted to carry Japanese tractors if prices and terms are right. What is more, the Japanese currency has depreciated recently, making Japanese manufacturers' tractors and Power tillers – previously expensive – more affordable for Ugandan farmers. Taking Power tillers, for example, the distributors told us that if the Japanese product are priced at about the double of those of their Chinese competitors, the Japanese Power tillers would be competitive enough.

At a farm equipment store run by Chinese people, female attendants were stationed to explain their merchandises, from Power tillers to rice mills, that were crammed into the display space, in order to boost sales. Although Chinese products have earned the negative reputation for unreliability, we assume that their affordability stimulates farmers' desire to get farming equipment. We also believe that the farmers who bought the Chinese products, after enjoying their usefulness, will want to buy better Japanese products, even if they are more expensive. In that sense, the Chinese are expanding the small-sized farm machine market for Japanese manufacturers. At the present moment, Uganda's GNI (gross national income) remains at US $500 per person, which is still low; and the Ugandan market certainly does not look attractive as it would still not be considered a mass market. However, it remains to be true that the market is steadily expanding.

2) Agricultural machinery manufacturers

The production of some farm equipment, which can be manufactured with elementary technology at small-sized enterprises, has started at certain private companies under the guidance of the Agricultural Engineering and Appropriate Technology Research Centre (AEATREC), an agricultural machinery research center. However, not only is the product variety small, but also the quality and efficiency of the local products is not necessarily high.

In planning for sales increase of cultivation machines, the success depends on how optimally to increase the variety of peripheral equipment in order to maximize the operation hours of the Power tillers. Japanese manufacturers may be able to help increasing the choice of peripheral equipment in some kind of way, which in turn will create a win-win situation for both the Ugandans and the Japanese.

3. Challenges for Japanese companies

1) Supply of spare parts

As we have noted previously, the Ugandan farm equipment market is expanding, and the trust for Japanese product is very high. Regrettably, however, post-purchase parts supply of the already-imported Japanese equipment is poor. This in turn results in a long down time for Japanese farming equipment, even if the cause of malfunction is relatively minor.

2) Determination of breakdown causes

We encountered farmers' claims that their farming equipment broke down. It is important for the manufacturers to identify the genuine causes in such cases and send feedback to concerned parties, as to if the malfunction is due to the way the farmers use the equipment, or if it is caused by manufacturing issues, or both.

For example, we need to know if the occasional coming apart of connecting parts is caused by the farmers' rough handling, or if the machines are originally designed for Thailand and Indonesia where such equipment is used to cultivate rice paddies filled with water, not the Ugandan fields. If the cause is the design issue involving the hardness of soil, it would be an idea to choose and recommend the equipment suited to cultivate Ugandan soils, so that the operating rate and life for Power tillers can be increased. This will in turn improve the reputation of Japanese products.

3) Operation induction and technical support

If the cause of breakdown were the incorrect usage by farmers, it would be important to allocate resources for operation training, as the vast majority of Ugandan farmers have not even experienced cultivation using cattle power. For the time being, we recommend that training be considered and administered for salespersons and repairpersons at dealers. As for the Ugandan government, the Agricultural Engineering and Appropriate Technology Research Centre (AEATREC) is mandated to provide research and training, but regrettably, it does not have the sufficient supply of researchers and technicians who have optimal level of knowledge and experience. If farming equipment manufacturers can proactively approach the institution, it is likely to make them appreciate the help.

4) Publicity and advertisement

In the present research, we have come up with a mechanization scheme, involving mostly Power tillers, as the aim is the promotion of mechanization for small-sized farms. On the other hand, we felt that the possibility for large-sized farming is promising for the northern region of the country, where farming is very active. For such areas, populated only in scattered ways in vast savannas, large-scale farming appeared to be suited. For that reason, the sparsely populated areas seem to have a larger need for large-sized agricultural machines. In fact, all the dealers we interviewed answered that they want machines with 80 to 100 HP.

Moreover, as we have noted before, cultivation outsourcing is penetrating the market, as individual purchase of farming equipment lags due to the underdevelopment of financing and subsidy systems. The outsourced Power tillers are seeking large-sized tractors in order to fulfill their tasks efficiently. For this reason, too, the Ugandan market for agricultural machines is expected to further grow in the near future.

Also, the used farming equipment market is growing, too, due to the rapid expansion of the tractor market. Although not as attractive as the newly-manufactured product market, this, too, seems to be important in the near future.

5) Latest agricultural machinery importation situation

In Uganda, the Uganda Revenue Authority (URA) compiles statistical data on the import and export of agricultural machines. Using the data obtained from URA, we will try to analyze the recent trend in this area. Note that the numbers listed below are obtained in a hearing from a URA official, and that they are not verified in final forms. It should be especially important to pay attention to the number for 2013, as it may not be statistically complete.

(1) The number of imported agricultural machines, by year

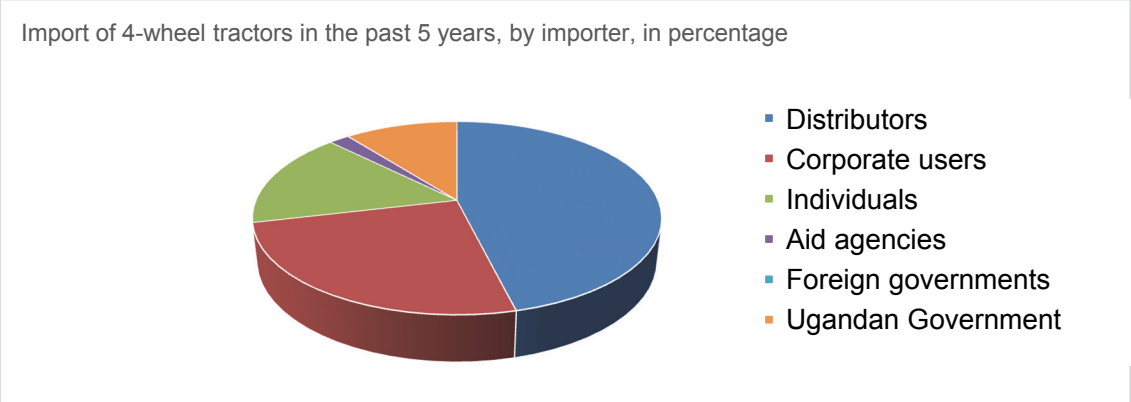
	2009	2010	2011	2012	2013	Total	Average
4-wheel tractors	434	451	398	619	505	2,407	481.4
Power tillers	187	305	455	451	68	1,466	293.2

An average of 480 units of 4-wheel tractors is imported each year since 2009. For Power tillers, an unnatural figure is listed for 2012, and we adjusted this, and came up with the average (estimated) annual import number of about 290 units.

Note: It is reported that in 2012, Evergreen imported 3,637 units of Power tillers from Italy. However, we have concluded that this is a statistical error, as the firm has never actually imported farming equipment before. This number has been subtracted from the adjusted figures in the chart above.

(2) The number of imported agricultural machines, by importers

	2009	2010	2011	2012	2013	Total	Percentage in all imports (%)	Average annual import
4-wheel tractors								
Distributors	151	255	209	261	234	1,110	46.1	222.0
Corporate users	131	124	119	85	148	607	25.2	121.4
Individuals	119	58	58	87	65	387	16.1	77.4
Aid agencies	8	9	10	8	11	46	1.9	9.2
Foreign governments				1		1	0.0	0.2
Ugandan Government	25	5	2	177	47	256	10.6	51.2
Total	434	451	398	619	505	2,407		481.4
Power tillers								
Distributors	86	164	272	416	0	938	64.0	187.6
Corporate users	42	26	33	15	3	119	8.1	23.8
Individuals	6	81	44	5	65	201	13.7	40.2
Aid agencies		9	103	13		125	8.5	25
Foreign governments		3				3	0.2	0.6
Ugandan Government	53	22	3	2		80	5.5	16
	187	305	455	451	68	1,466		293.2



By importer, the percentage of distributors is around 50%. Meanwhile, large-scale agricultural companies at times choose to import farming equipment by themselves when needed. It should be noted that individuals account for more than 10% of all imports. As the import by the Ugandan government is only about 10%, we can safely assume that the import of agricultural machines is led by the private sector, and that the influence of government imports is limited.

(3) Imports from Japan, by importer

4-wheel tractors	2009	2010	2011	2012	2013	Total	Percentage in all imports (%)
Distributors	0	0	0	0	1	1	1.6
Corporate users	3	2	4	0	2	11	17.5
Individuals	11	8	13	8	11	51	80.9
Total	14	10	17	8	14	63	100.0

Power tillers	2009	2010	2011	2012	2013	Total	Percentage in all imports (%)
Distributors		3	8			11	18.3
Corporate users			9			9	15.0
Individuals	1	31	1	3	1	37	61.7
JICA		2				2	3.3
Others		1				1	1.7
Total	1	37	18	3	1	60	100.0

Since the start of 2009, a total of 63 Japanese tractors and 60 Japanese Power tillers have been imported to Uganda in the 5-year period, according to the numbers. These are 3.7% of all tractor imports and 4.1% of all Power tiller imports, respectively. Although these figures are very small compared to the sizes of the markets, but it is hoped that active marketing efforts will be made in anticipation of a further expansion of the markets.

The number of Japanese Power tiller imports in 2013 stood at only 1 unit. On the other hand, officials at Akamba, a company that markets Honda Power tillers in Uganda, told us that an average of 6 units of Honda Power tiller are sold per year. Therefore, it is probable that some Japanese imports are not reflected in the government's import statistics.

In any case, as we have noted, a total of 60 Japanese Power tillers – an average of 12 units a year – have been imported in Uganda in the past 5 years. It is expected that demand will remain at least at this level for the foreseeable future. Other Japanese imports sold in Uganda include the products made by PT. Yanmar Diesel Indonesia in Indonesia, and Siam Kubota Corp. in Thailand.

By importers, it is noted that imports of Power tillers made by Japanese manufacturers are mostly carried out by corporate users and individuals, as dealer imports are only few. We believe that the discovery and development of excellent dealers would make it possible to systematically market Japanese products, and to supply parts in a stable fashion.

Note that some or all of individual imports are used products. On the other hand, sales of parts will increase anyway if the import of main products rises, even if they are pre-owned. In addition, we

believe that the longer Ugandan farmers use farming equipment made by Japanese manufacturers, the more durability those products will display, and that in turn is expected to prove their economic performance. This will win more trust for the Japanese products.

With regards to the trust in Japanese products, we noted that in Uganda, Indian-made motorcycles started to rapidly become popular, overwhelming competitors from other countries. This can be attributed to the soaring demand for (inexpensive) motorcycle taxis, as well as the popularity of low-price motorcycles that succeeded in penetrating in the rising middle class in urban areas induced by the country's economic growth. On the other hand, the share of Japanese-made motorcycles in rural areas has not dropped. This may be attributed to the fact that benefits of urban economic growth have not fully reached rural areas (and therefore funds available for motorcycle purchase is still small), and that replacement demand for Japanese motorcycles is not strong because they have excellent durability and our informants tell us that old Japanese-made motorcycles are still in use in those areas.

For Japanese manufacturers, sales of pre-owned agricultural machines may not be directly beneficial for their performance. At the same time, however, a further penetration of Japanese brands potentially leads to the increase in the sales of newly-manufactured products. For that reason, the used product market cannot be entirely ignored.

(4) Import by manufacturer brand

The following is the breakdown of tractor imports in Uganda by manufacturer brand in 2013: 79 units of Massey Ferguson tractors, 54 units of New Holland, 24 units of John Deere, 18 units of Iran's ITMCO, 12 units of India's TAFE, 11 units of Mahindra of India, followed by 10 units of Mitsubishi. In the case of tractors, most popular products are mostly over 80 HP. What stands out among the imports, there are some 18.5-HP product made by Mitsubishi Shakti of India. While the customers at estates and outsourced cultivating businesses prefer large-sized tractors, it seems likely that demand is also rising for the Mitsubishi Shakti products that have a tight turning circle and thus are suited for mall- and mid-sized farms.

A total of 4 distributors sell Massey Ferguson (MF) products. However, those MF products are manufactured in and exported from 5 different countries: the United Kingdom, Brazil, India, Pakistan, and Kenya.

The dealers told us that the popularity derives from the reliability of the body itself, as well as the relatively wide availability of repair parts. On the other hand, they also told us that mechanical details of Massey Ferguson products differ from a manufacturing country to another, and that they do not necessarily use the same components. For this reason, it is possible that MF products made in certain countries will be weeded out in Uganda in the future.

Chapter 5 Outline of Rice Growing Promotion Cooperation between Tanzania and Japan

1. Current Status of Rice Cultivation

Tanzania is located in the eastern part of African Continent. Its total land area is about 950,000 km2. Kilimanjaro, the highest mountain in Africa (5,895m), Lake Victoria, the largest lake in Africa and Lake Tanganyika, the deepest lake in Africa, are all located in this country.

The population in Tanzania has increased to 45 million people in 2012 from 12 million people in 1967. Rice has been getting popular gradually in Tanzania and the annual consumption of rice per capita has increased to about 20 kg in 1988 and to about 30 kg in 2012 from about 8 kg in 1967 (Table 5-1).

Table 5-1: Population in Tanzania and Changes in Rice Production, Trades and Consumption

	1967	1978	1988	2002	2012*	2012/1967 *
Population (×1,000)	12,313	17,513	23,096	34,444	44,929	3.65
Chaff production (×1,000t)	116	321	659	983	2,024	17.45
Rice import (×1,000t)	19	42	31	135	50.9	2.68
Rice export (×1,000t)	0.66	0.08	0	8.8	35.1	53.18
Rice consumption (kg/head/year)	7.6	14.3	19.9	22.2	29.6	3.89

Note: Population is based on population census, and the information related to rice is based on FAOSTAT.

The information related to rise for 1967, 1978, 1988 and 2002 is the average of data recorded over the last 18 months and after 18 months.

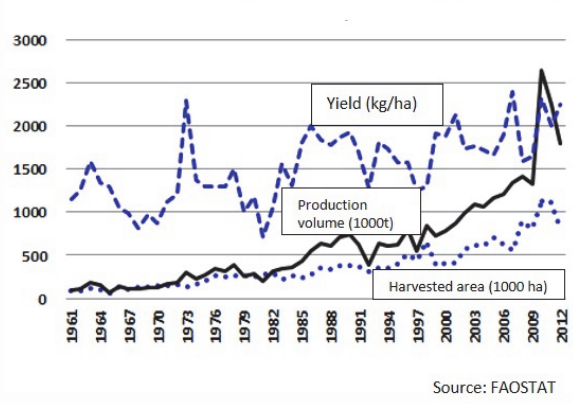
*The production volume of chaff in 2012 is the average of the volume in 2011 and 2012.

*The rice import volume in 2012 and the rice export volume in 2012 is the data recorded in 2011 respectively.

Rice consumption is assumed based on the population, rice production volume (chaff production volume ×0.65) and rice export volume.

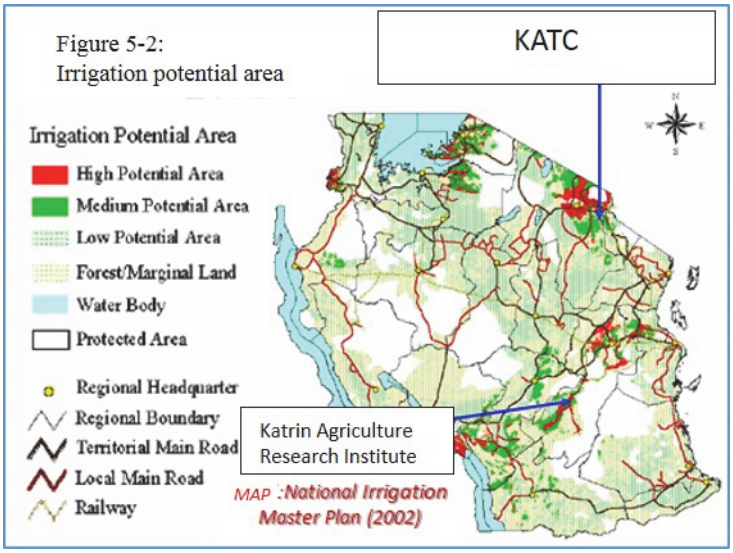
According to the statistics from FAO, the rice (chaff) production volume in Tanzania has increased 94,000 tons in 1961 to 2,248,000 tons in 2011. At the time of its independence (1961), the harvested area of rice was 82,000ha and since then, expanded to 153,000 in 10 years, 280,000ha in 20 years, 369,000ha in 30 years, 406,000ha in 40 years and 1,119,000ha in 50 years. On the other hand, the growth rate of rice production is low (Figure 5-1).

Figure 5-1: Rice harvested area, production volume and yield (1961 – 2012)



Tanzania Agriculture Sample Consensus (2007/08) states that the rice has been cultivated by about 1,162,000 farmers across the country (main land and Zanzibar). Shinyanga Region accounts for 19.3%, Morogoro Region and Mwanza Region account for 13.7% respectively and Tabora Region accounts for 11.0% to the total area of rice cultivation, which are all relatively high. The shares of rice cultivation of each region to the total cultivated acreage in each region is high as follows: Morongo Region (31.0%), Zanzibar Region (22.2%), Mwanza Region (14.8%) and Dar es Salaam Region (11.8%). The rice cultivation area per farmer is large in Rukwa Region (1.34ha), but small in Zanzibar Region (0.37ha). Rice cultivation volume is large in Manyara Region (3.4t/ha) and Rukwa Region (2.74t/ha), but small in Dodoma Region (0.7ha).

The area suitable to irrigation in Tanzania is seen mainly in the northern part (at the foot of Kilimanjaro), the northwestern part (lakeside of Victoria) and the southeastern part (in watershed area of Rufiji River and lakeside of Malawi) of the country (Figure 5-2). These areas are used not only for irrigated rice cultivation but also for cultivations of sugar cane, other dry-field crop and perennial crop.



2. Historical background

Since the 10th century BC or so, there had been oceanic commerce between Africa and Asia. It is said that the Asian rice arrived at East Africa (Zanzibar and Kilwa) approximately 2000 years ago and they started living on rice (Pilau, Biryani), Arab merchants' favorite foods, in the 8th century AD or so spread across Zanzibar. In the 19th century, rice was brought into the inland area of Tanzania by trade based in Zanzibar. In 1870s, rice was produced along River Rufiji to export to Zanzibar.

In 1886, German companies that run colonies moved into this area and the main land of Tanzania became one of German colonies in 1890. German introduced cotton in 1904 or so, and the railways to connect Dar es Salaam and Lake Tanganyika (Kigoma) were opened in 1914.

The main land of Tanzania was under control by United Kingdom as League of Nations' mandate territory in 1919 and onward after the World War I and as United Nations' trust territory after the World War II. The British Government of the Mandate Territory cut down trees in its habitat from 1923 to 1929 in order to exterminate tsetse flies transmitting African sleeping sickness (zoonosis). In 1928, the construction of railway between Tabora and Mwanza was completed connecting Mwanza

and Dar es Salaam. In 1934, cultivation with cattle (plough) was introduced, which enabled to till heavy soil with impermeability layer (vertisol) much easier. As cotton became their main cash crop, cultivation with cattle spread among people in 1945 or so. The Government of Tanzania became independent in 1961 and promoted cotton and this resulted in expansion of cotton cultivation area mainly in Sukumaland.

It was Arab merchants that settled down there and started rice cultivation in Sukumaland. Initially, producing rice was not as stable as producing millet or sorghum, so seemingly the inhabitants took little interest in rice cultivation. It is said that the Indian immigrants started making furrow and ridge for rice cultivation in 1920s. In 1930s, rice cultivation was gradually accepted in Sukumaland and became their valuable crop. The farmers developed rice paddy in the valley area and surrounded with small furrow and ridge around the rice paddy to hold rain water and surface stream water back for rice cultivation. In 1938 in Nzega in Tabora Region, the farmers constructed rice paddy with furrow and ridge where there were less weed than the rice paddy without furrow and ridge and the volume of crop increased. Sukuma is the biggest ethnic group in Tanzania and they tend to keep many cattle and have wealth. In Sukumaland where the cultivation areas of cotton and rice were wide-spread, but their range land became insufficient and certain part of Sukuma started moving with their cattle to other places in Tanzania seeking grazing ground (especially southern and southern east areas). Pastured cattle by Sukuma and Maasai had sometimes conflicts with the original inhabitants, but some Sukuma settled down in the places suitable for rice cultivation and they expanded cultivation with cattle and cultivation with furrow and ridge.

The Government of Tanzania opened 12 animal power training centers (in 10 regions) in 1970 and 80 centers up until 1990. In 1970s, they started production of farm equipment for animal power and human power. During 1990 to 1995, some projects using animal power were implemented in Mbeya Region, a southern east part of Tanzania and in Tanga Region, a northern east part of Tanzania.

In Tanzania, it is said that human power accounts for 70%, animal power accounts for 20% and machine power accounts for 10% to the total plowing and tillage operations. Plowing and tillage by using cattle is popular in Shinyanga Region, Mwanza Region, Mara Region, Mbeya Region, and Iringa Region.

According to “Lower Moshi Agriculture Development Plan Implementation and Research Report (October 1980)” explains about the places to be developed as “the original inhabitants in low land have to live with much severer living condition, such as high temperature, drought, flood, soil with high sold content, lack of water, malaria, schistosomiasis and so on. Their living mode is more like the one in the primitive age, and the most of the original inhabitants live in a small and simple shed with mad walls and banana leaves without floor. Since there is no investment in the public facilities and social infrastructures, the villages there remain undeveloped”.

The same report also explains about the irrigation facilities as follow; “the density of the existing drainage network is small, especially the third drainage and the terminal agricultural fields have little ditch. In Lower Moshi District, there is no drainage ditch at all. Drain is an earth canal, and the water volume lost is huge. The irrigation operation at the terminal canal is not efficient since it is impacted by the method of cultivation and the land features, and there is no general rule. The irrigated water cannot be penetrated equally over land with small undulations on its surface. Therefore, in order to implement surface irrigation effectively, leveling and land readjustment are necessary”. As reference, according to the same report, the volume of chaff crop by irrigated rice cultivation at that time in Lower Moshi District was 1.4t/ha.

Such a scene could be seen all over Tanzania. As time went by, the irrigation facilities were gradually constructed and organized in some part of water-rich areas (initially as state-owned farm and collective farm) and the irrigated rice cultivation was introduced. The farmers actively opened the rice fields in areas around the irrigated lands and the neighboring suitable lands. In some areas, construction of trunk lines and branch roads triggered their agricultural development.

3. Study on Rice (mainly variety improvement)

The Government of British Mandate Territory took interest in rice cultivation and in 1935, the Government started study on rice in Mwabagole by Lake Victoria. In Mwabagola, they tried refining the existing breed and improving the cultivation technologies, but suspended their activities in 1956 due to cuts in the budget. After its independence, the study on rice was restarted in 1965 at ARI-Ilonga (Ilonga Agriculture Institute) in Morogoro Region, and in 1980s and onward, KATRIN (Kilonbero Agriculture Training and Research Institute, currently ARI-Katrin in Morogoro Region) became their main base for the study on rice. In 1972, the study on rice was started also at Dar es Salaam University Agriculture and Forestry Department (current Sokoine University of Agriculture: SUA).

In the field of rice research, high-yield cultivar, resistibility against pests and diseases, reactivity to nitrogen (short-stalked), shattering habit resistant characteristics, high protein content were drawing attention. IR8 was selected in 1970s from the breed introduced by International Rice Research Institute (IRRI) and IR579 in 1980s and they were cultivated at the irrigated farm possessed by National Agriculture Food Company (NAFCO). In 1980s, Dakawa 83, Katrin, and Subarimati were registered (for rain-fed lowland). These breeds were not widely used.

The most popular rice breed (Supa) was thought to be introduced from Suriname (South America) in 1960s. Supa is a long-stalked late maturing variety, aromatic rice with good eating quality and has been cultivated in rain-fed lowland swamp and dry field, but it is easy to be dropped under good cultivation environment.

In 1982, ARI-Dakawa (called ARI-Cholima) was established in Morongo Region and Supa improvement project was started. In 1999, TXD 85 (a successor of Supa/KM67), and in 2002 TXD88

(a successor of TXD85/Supa) and TXD 306 (SARO 5) were all registered (TXD phyletic line is grown in Dakawa, Tanzania). SARO 5 is a crossbreed successor of Supa/P8 (Pyongong 8) and Subarimati/Supa. SARO 5 is aromatic rice with high yield, but weak against blast disease, bacterial leaf blight and fungus causing yellow spot and if its proper season of harvesting is missed, the crushing rate seems to be higher.

At SUA, they have worked on mutant breeding with the support from International Atomic Energy Agency (IAEA) and Mwangaza was registered in 2005 from a successor of the seed (Supa) radiated by cobalt 60 gamma ray at IAEA in 1994. At the same time, a phyletic line (H232-44-1-1-1) introduced from Africa Rice Center (Africa Rice) was registered as Kalala, a name of breed. Both of them are strong against fungus causing yellow spot, but the yield is the same as Supa (2–3t/ha) and these are not aromatic rice.

A dry-land rice breed (NERICA) was given from a project called "African Institute of Capacity Development" jointly promoted by AfricaRice and JICA in Kenya from 2001 to 2006 and a preliminary test was conducted at ARI-Katrin. In cropping season 2007/08 and 2008/09, the breed comparison test was conducted at 6 dry-land rice cultivation areas and at the end of 2009, five breeds (NERICA 1, NERICA 2, NERICA 4, NERICA 7, and WAB450-12-2-BL1-DV4) were registered. Among them, NERICA 1 is aromatic rice. In Zanzibar, after going through the same process, three breeds (NERICA 1, NERICA 10 and NERICA 12) were also registered.

In 2013, Komboka (IR05N 221) and Tai (IR03A 262) were registered from the phyletic line introduced by IRRI. Kombaka is the first aromatic rice introduced by IRRI into Tanzania.

In addition to ARI-Katrin, ARI-Dakawa and SUA, the research on rice has been conducted at ARI-Mikocheni (Dar es Salaam Region), ARI-Naliendele (Mtwara Region), ARI-Tumbi (Tabora Region), ARI-Ukiriguru (Mwanza Region), ARI-Uyole (Mbeya Region) and ZARI (Zanzibar Agriculture Research Institute). As for breed, efforts will continue to be made for improvement and not only its yield but also its eating quality (especially aromatic characteristics), resistance against disease (especially against fungus causing yellow spot), early-growing characteristics/drought resistance (especially dry-land rice and rain-fed lowland swamp rice), quality (especially crush resistance) and resistance against cold weather damage (for highland) will draw attention.

Rice research program has been conducted jointly with World Bank East Africa Agriculture Productivity Program (EAAPP), IRRI and AfricaRice. ARI-Katrin is also a base for EAAPP rice research including Uganda, Ethiopia and Kenya, organizing the research facilities and equipment as well as strengthening the capacity of each researcher and improving the seed production system of the related authorities.

JICA supported registration of NERICA breeds in mainland of Tanzania and Zanzibar through Irrigated Agriculture Technology Promotion Support Scheme Enhancement Plan (called "Tanrice") to be explained in latter part of this report, and AICAD. Also including short and long-term trainings

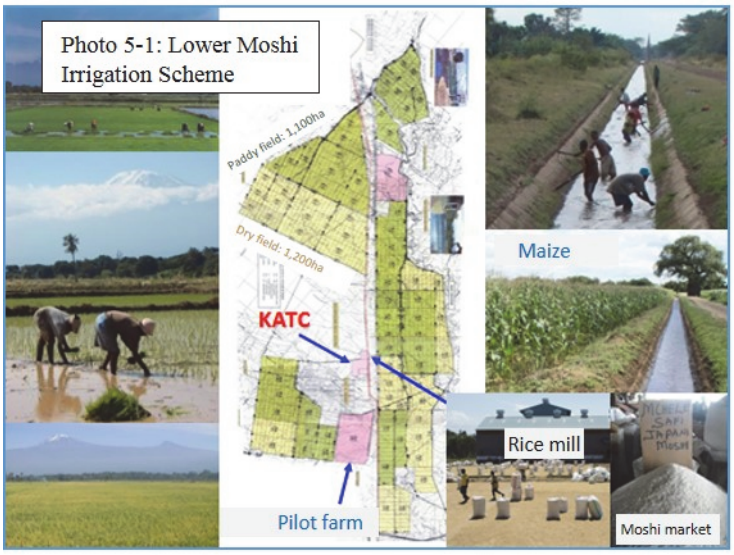
in Japan, they cooperated for strengthening the capacity of each rice researcher. In the future, the cooperative relationship with JICA will be maintained for promotion of rice cultivation in Tanzania.
As for rice seeds in Tanzania, ARI and SUA supposed to produce Breeder Seed and Pre-basic Seed, Agricultural Seed Agency to produce Basic Seed and Certified Seed, some private companies to produce Certified Seed and seed producers to produce Quality Declare Seed. These seeds will be inspected at Tanzania Official Seed Certificate Institute. During cropping season 2011/12, 26.7t of Pre-basic Seed, 37.5t of Basic Seed, 816t of Certified Seed and 83.5t of Quality Declare Seed were produced. In 2012, Certified Seed (816t) produced at ASA accounted for only 5% of the total rice cultivation area in Tanzania. In case of rice most of the seeds is chaff produced by the farmers (it is not certified as seed) and some of them are distributed among the farmers (or among areas). Good quality seeds contribute to the yield and the quality of rice cultivation, and in order to increase its popularity, it is necessary to consider not only its production technology but also its distribution system.

4. Irrigated Rice Cultivation Development and Cooperation in Kilimanjaro Region

The Government of Tanzania asked one region and one developed nation for cooperation for the integrated development plan for the main regions in making the third five-year plan (1977–1981) and the Government of Japan agreed to cooperation for development in Kilimanjaro Region. JICA submitted in February 1978 “Kilimanjaro Region Integrated Development Plan (Master Plan)” to The Government of Tanzania and cooperated for establishing the high-yield irrigated rice cultivation technology through “Kilimanjaro Agriculture Development Center (KADC) from 1978 to 1986. In 1981, the construction of KADC (Kilimanjaro Agricultural Training Centre) was completed with the aid of free financial support.
In KADC, they started the experimental irrigated rice cultivation in April 1982 at the test farm (about 10ha, of which, rice paddy is 2.4ha). At the test farm, while even facing with drought (due to failure in water pumping and lack of fuel for pump), damage by birds and cold weather damage, selection of the breeds, establishment of standard for selecting seeds for cultivation and seed multiplication. In November 1982, a pilot farm managed by Chekereni Village (about 100ha, out of which, rice paddy is 18.9ha) started teaching wet-rice cultivation. Chekereni Village was opened in July 1970 as Ujamaa Village and the villagers jointly engaged in the agricultural activities (rice cultivation, dry-field cultivation and cattle farming) on their common lands. The pilot farm initially suffered from lack of maintenance and management of the irrigation facilities, short irrigation time, difficulties in water transmission to individual farm land, low labor motivation and lack of materials for production. By the guidance by KADC, high yield achieved by the irrigated rice cultivation and high profitability were proved, which created opportunities for the villagers and neighboring people to take interest in rice cultivation.

By KADC Plan, the capacity of the related parties (counterpart, agriculture promoters, tractor operators and farmers) was strengthened in the field of crop, irrigation and agricultural equipment. The technologies and skilled proved by KADC for irrigation, agricultural equipment and rice cultivation were promoted to Lower Moshi Irrigated Site (LMIS) organized by the loan aid cooperation project (1982–1987) through Kilimanjaro Agriculture Development Plan (KADP) (1986–1993)

At LMIS, it was planned that surface water and spring water from the base of Kilimanjaro was taken at dams at the two points on River Lao and introduced through main waterway (10.1km), the second canal (24.6km), the third canal (65.6km), and the terminal canal (72.9km) to rice paddy (1,100ha) and dry field (1,200ha) for irrigation. As for the canal for the rice paddy, channel lining using concrete was implemented up to the third canal. Each rice paddy was adjoining to the drainage channel and this is the first drainage-separated irrigation district (Photo 5-1).



Rice cultivation technologies recommended by KADP for LMIS are mainly; proper breed (IR54 and IR56), good quality seeds and rice seedling (group rice nursery), preparation of farm field (ditch, weeding in farm field), mechanization (dry-field plowing, letting puddling and leveling the field with water), planting time (about 25 days after seeding), proper planting density (20cm for both of space between planting rows and intra-row spacing), proper fertilization (urea 100kg/0.3ha: half basal fertilizer/additional fertilizer twice, triple superphosphate 25kg/0.3ha: basal fertilizer) and proper seasonal management (weeding, water management, harvesting, thrashing). They had some obstacles in improving irrigated rice cultivation technology, but the rice plant grown in the group rice nursery was transplanted mostly in accordance with the water distribution plan, all grown and ripened, and the yield of chaff was over 6t/ha. In late 1990s, IR64 was introduced, and in early 2000s, LMIS gained popularity.

At LMIS, it was planned to cultivate 1,100ha during the first cropping season (January–June) and 800ha during the second cropping season (July–December), but it was not realized due to lack of irrigated water because the ground saturation water from the rice paddy was larger than expected and the rice fields were opened in the upriver areas. So, from 1988 and onwards, they decided to cultivate three times a year (it is not triple cropping) and the area for rice cultivation was 923ha in 1987 (the

yield of chaff: 6,163t) and increased to 1,525ha in 1990 (the yield of chaff: 9,943t) and the total yield of chaff exceeded the planned yield (Table 5-2).

Table 5-2: Rice and corn crop acreage (ha), production volume (t) and yield (t/ha) in Lower Moshi District

	Rice (chaff)			Corn (idle farm land during the rainy season)		
	Crop acreage	Yield	Production volume	Crop acreage	Yield	Production volume
Planned	1,900	4.5	8,550	-	-	-
1987	923	6.7	6,183	-	-	-
1990	1,525	6.5	9,943	-	-	-
1995	468	6.2	2,878	-	-	-
2001	1,009	6.5	6,558	-	-	-
2008	517	7.0	3,611	585	4.5	2,633
2013	419	6.4	2,679	684	4.3	2,942

Impacted by opening fields in the upriver areas and expanding the dual cropping area, the volume of irrigated water to LMIS decreased. In LMIS, it became difficult to meet the administrative guidelines and a dual cropping of rice was implemented in the irrigation blocks near the source of water while they started cultivating corn instead of rice in the down streaming areas.

Not only organizing the irrigation facilities through the loan aid cooperation project and establishing technologies for cultivation through technical cooperation, but also proper seasonal operation by using the tractors and machines (rotary, drive harrow) given by the aid toward increased food production (2KR) and large-scale rice mill constructed through free financial aid in 1989 contributed to development of rice cultivation at LMIS. Each rice paddy (standard unit 0.3ha: 30m × 100m) made easy and direct access to drain, ditch and farm road possible and also made easy water management, mechanization and transportation of materials (input and product) possible.

Net income out of independent farming per LMIS's standard area of rice paddy (0.3ha) was US$618 in 1986 (immediately after the rice cultivation was started; 72% of the gross income), US$275 in 1990 (59% of the gross income) and US$327 in 2011 (44% of the gross income). Farm rent per LMIS's standard area of rice paddy was US$64 (1986) and increased to US$102 (1990) and US$135 (2011), and the net income earned by the peasant was 65% out of the gross income (1986) and decreased to 37% (1990) and 26% (2011) (Table 5-3).

About 3,000 farmers are cultivating rice at LMIS and one third of which is tenant farmer. Development of rice cultivation at LMIS and neighboring areas provided job opportunities for independent farmers and tenant farmers as well as many inhabitants. Their houses described as "a small and simple shed with mad walls and banana leaves without floor" were gradually upgraded to a house with block-made

or baked-mud made wall and zinc-roof top. Some of the people who learned the method for the irrigated rice cultivation at LMIS started opening rice fields on land suitable for rice cultivation in neighboring regions.

Table 5-3: Profits and expenses out of rice cultivation in Lower Moshi Irrigated District (per 0.3ha)

	November 1986		October 1990		March 2011	
	US$	%	US$	%	US$	%
Production cost	305.2	100.0	296.1	100.0	551.3	100.0
(farm rent)	64.4	21.1	102.0	34.5	135.1	24.5
Preparation for farm field	14.4	4.7	10.3	3.5	40.5	7.4
Transplanting	32.2	10.5	25.5	8.6	33.8	6.1
Fertilizer	17.2	5.6	9.2	3.1	93.2	16.9
Weeding	21.5	7.0	15.3	5.2	54.1	9.8
Cattle droving	21.5	7.0	15.3	5.2	54.1	9.8
Harvesting	53.6	17.6	31.9	10.8	67.6	12.3
Other costs	80.5	26.4	86.6	29.2	72.9	13.2
Gross income	858.4	100.0	469.4	100.0	743.2	100.0
Net income (independent farmer)	617.6	72.0	275.3	58.7	327.1	44.0
Net Income (tenant farmer)	553.2	64.5	173.3	36.9	191.9	25.8

Notes:
(1) Assumed that the yield of chaff per standard rice paddy (0.3ha) is 25 bags (80kg each)
(2) The price for chaff (T. Shs./kg) is 20 (1986), 46 (1990), and 550 (2011).
(3) Official price (T. Shs./US$) is 46.4 (1986), 196 (1990), and 1,480 (2011).

In Tanzania, decentralization of government to local jurisdictions and privatization were promoted since the middle of 1980s. Therefore, LMIS initially operated mainly by Kilimanjaro Region (KADP) and Water Utilization Association (WUA) started being operated mainly by the rice plant producer union (CHAWAMPU) since 1993 or so. Unfortunately, management and maintenance of the irrigation facilities and providing rental cultivation service by CHAWAMPU and management of the rice milling facilities jointly with KNCU (Kilimanjaro Native Inhabitant Cooperative Union) and CAWAMPU were not smooth. In 2007, Lower Moshi Irrigation Association (LOMIA) was established including the rice cultivating farms in the upstream areas at LMIS, led by the Government and under the circumstances, LOMIA and CHAWAMPU co-existed. Since the farmers were reluctant to reach a compromise and the local government (of Moshi) did not have enough ability for leadership, however, harmony between the related farm villages has not been created yet.

About four and a half centuries has passed since the construction of LMIS. Meanwhile, JICA conducted "Tanzania Lower Moshi Agriculture and Farm Village General Development Plan Research" and proposed expansion of the rice cultivation area by transmitting water from Kikuletwa River in 1998, but passing the entitlement of water to the relevant party became tangled and it was not materialized. Using Grant Assistance for Grassroots Human Security Project, main watercourses at LMIS were refurbished from 2007 to 2009. For managing the water source and irrigation water, maintenance of the irrigation facilities, management of the irrigation organization and improvement of management of the rice milling facilities, it is important to strengthen the abilities of the agricultural organizations and the related authorities.

In 1990, intake weir, drain, ditch, farm road, rice paddy (670ha), and the rice milling facilities were all organized for Ndungu Irrigation Site (NIS) in Same, Kilimanjaro Region with free financial cooperation and tractors and operation machines were provided by 2KR. KADP supported promotion of the irrigated rice cultivation technology by training NIS officers, tractor drivers and farmers. At NIS, there was not lack of irrigated water issue, but as for the irrigation facilities, agricultural machines and maintenance of the rice milling facilities, they have the similar issue to that of LMIS. Under the leadership by the Government, they have been active in revitalization of NIS in Same since 2007.

5. Training for Promotion of Rice Cultivation across Tanzania

1) KATC Plan to KATC Phase II Plan

In order to improve the rice cultivation across Tanzania, the Government of Tanzania transferred control of KADC that was under control of the Region, to the Government and changed its name to KATC (Kilimanjaro Agriculture Training Center). Their tasks under KATC Plan (technical aid, the initial aid period: 1994–1999) are "strengthening the technology level of the training leaders, improving the training method and the training materials and improving the methods of training and promotion for the government officials and the core farmers for the irrigated rice cultivation in the field of agriculture promotion, training, rice cultivating, water management and agricultural machine". Agriculture and cattle farming development officers in each region in Tanzania who participated in the KATC workshop requested the similar irrigation facilities and the agricultural machines in order to promote LMIS's rice cultivation technology across Tanzania. The pre-conditions for the irrigated rice cultivation (management of furrow and ridge, rice field leveling) were common in Asia at that time, but were not common in Tanzania.

Workshop participants were guided to LMIS and they saw the rice paddy there, equally smooth and surrounded by furrow and ridge and rice plants equally growing and ripening in the paddy. The basic in improving the rice cultivation is "cultivate equally ripened rice plants". So, usage of same breeds, seeds, germination condition, rice nursery management, leveling the main rice field, fertility in soil, rice planting density, water management and growing pattern were all stressed. Also it was strongly

explained that if they had enough water sources, it would not be always necessary to use heavy equipment or agricultural machines. Such a simple message made it easier not only for the officer in charge of development of agriculture and cattle farming, but also for the officers in charge of training, the agriculture promoters and the core farmers to understand the rice cultivation technology.

Under KATC Plan, 1) every time about 20 agriculture promoters participate in the rice cultivation training course (for 38 days to 45 days, 7 times), 2) each promoters who completed this course participate in the core farmer course (for 12 days to 19 days, 14 times) together with three core farmers and 3) made an action plan based on participation-type approach to mainly demonstrate the irrigated rice cultivation technology. In this action plan, preparing furrow and ridge, displaying breeds and transplanting rice cultivation and maintaining drains and so on were all included.

It was expected that the irrigated rice cultivation technology was promoted by using the resources possessed by the farmers (land and input) through "joint trainings with the agriculture promoters and the farmers" under the tight budget with "the structure adjustment measure". These expectations were materialized in relatively nature-rich environmental areas. During the extended period of KATC Plan (1999–2001), the training on site and the cyclic guidance were conducted in the irrigation district (village) where those who finished the training are living.

Under KATC Plan, the trainings by other donors were actively conducted on a commission basis. Lekitatu irrigation district (the irrigated area 600ha, among which, the rice cultivation area 400ha), located at about 1,300m elevation in Arusha Region and west to Kilimanjaro Region, has a little bit cooler in temperature so that it takes longer for the rice plant to grow. World Bank repaired the drain in Lekitatu and entrusted KATC to conduct the training for the farmers. The farmers participated in the trainings introduced early rice, Wahiwahi (aromatic rice), and made the dual cropping possible. Wahiwahi was found in the farm field held by the farmer in Kilimanjaro Region and refined in KATC farm field.

Under KATC Phase II Plan (2001–2006) succeeded from KATC Plan, the training on the irrigated rice cultivation was conducted and promoted for six domestic model sites in Tanzania (one site per each irrigation zone). The training under this Plan, they aimed at balancing the ratio at 50:50 between male and female participants in the training, taking the gender into consideration. They focused simple agricultural tools and made efforts to promote push-type weeder and simple thrashing machine (grain beating table). They also selected one irrigation district from four neighboring countries (Uganda, Kenya, Malawi and Zambia) as model site and conducted the workshop at KATC for the related parties, "the joint training with the agriculture promoters and the farmers" and the training on site in these countries in the same manner as they did in Tanzania.

2) From Tanrice to Tanrice 2

The authorities that conducted the Irrigation Agriculture Technology Promotion Support Scheme Strengthening Plan (Tanrice, 2007–2012) were five agriculture training centers (including the one in Zanzibar) and the Rice Study Program (six Agriculture Research Centers). At the trainings for the officers at the Agriculture Training Centers and the seminars for the officers and the related parties at the main rice cultivating provinces (cooperative entities), the approach "he joint training with the agriculture promoters and the farmers" that KATC conducted was introduced (Photo 5-2).

At the irrigated rice cultivation training, for 44 irrigation districts, 1) the research on site (about 50 participants), 2) the group training (two promoters, two leading farmers, and eight male and eight female core farmers), 3) the training on site three times (rice nursery, preparation timing, rice planting timing, harvesting timing, three to five middle-class farmers/core farmers), 4) the review meeting on site at the third training on site (the related parties and the general farmers were invited) and 5) confirmation of progress and making plans twice (after harvesting and one year after completion of the training were all conducted (some of them could not be completed during the project cooperation period). When the district for the training was selected, the incentive the province has for the project (securing the budget) was put in top priority. The province was expected to be responsible for a half of the training expenses (about US$20,000 per site).

In Tanrice, they aimed at increasing the yield of chaff per eligible irrigation district by 1t/ha. By completion of the project, the average yield of 30 irrigation districts during their main harvesting season based on the yield data collected before and after the training increased to 3.7t/ha from 2.6t/ha, but only 16 districts achieved the target (Table 5-4).

In the districts eligible to the training provided by KATC and Ilonga Agriculture Research Institute, the yields were on upward trend. On the other hand, Igurusi Agriculture Research Institute had many districts for the training (ten districts), only two districts increased the yield by more than 1t/ha, and the yield went down in four districts. The main causes of decrease in the yield were flood, drought, and disease (especially, fungus causing yellow spot). In order for the irrigated rice cultivation research in Tanrice to contribute to improving the yield, it is necessary that the irrigation facilities (irrigation water) as precondition and the cultivation environment as external condition are satisfied.

Among 33 irrigation districts where the research on the current status of rice cultivation was conducted (sometimes, the research was conducted at multiple district at a time), the farmers in ten districts did not use fertilizer, 1–33% of the farmers in eight districts used fertilizer, 34–66% of the farmers in three districts used fertilizer, 67–99% of the farmers in seven districts used the fertilizer and 100% of the farmers in five districts used the fertilizer. The irrigation districts where all of the farmers used fertilizer are located in Arusha Region, Kilimanjaro Region and Zanzibar (three places) and the volume of nitrogen fertilizer ranged from 55–115kg/ha. The irrigation districts where the farmers did not use fertilizer are located in Tanga Region, Morogoro Region, Rukwa Region, Mbeya Region, Kigoma Region and Mwanza Region.

Table 5-4: Comparison of yield of chaff before and after the training in irrigation district of Tanrice Project

Agriculture Research Institute	Decreased Yield	Unchanged Yield	Increased Yield		Total
			Less than 1t/ha	1t/ha or more	
KATC, Moshi	0 (0)	0 (0)	0 (1)	4 (1)	4 (2)
MATI-Ilonga	0 (0)	0 (0)	1 (1)	7 (1)	8 (2)
MATI-Igurusi	4 (0)	0 (0)	4 (0)	2 (0)	10 (0)
MATI-Ukiriguru	1 (0)	1 (0)	2 (0)	1 (0)	5 (0)
KATI, Zanzibar	1 (0)	0 (0)	0 (0)	2 (0)	3 (0)
Total	6 (0)	0 (0)	7 (2)	16 (2)	30 (4)
%	20 (0)	3 (0)	23 (50)	53 (50)	-

(1) Changes in yield of chaff before and after the training during the main cultivation period in 30 irrigation districts
(2) Figures in bracket show changes in yield of chaff in four irrigation districts where the dual cropping was introduced
(3) The average yield of chaff during the main cultivation period increased by 1.1t/ha (2.6t/ha →3.7t/ha)
(4) The average yield of chaff by dual cropping increased by 0.8t/ha (2.6t/ha→3.4t/ha)
(5) The main causes for the decrease in the yield are flood, drought and disease damage

According to "The Survey on Promotion Among the Farmers" conducted by JICA in 2012 for four irrigation districts, Mussa Mwijanga, relatively close to KATC, the basic conditions for the irrigated rice cultivation (good furrow and ridge, surface smooth rice paddy, and rice planting in straight lines) were substantially met even before the training, and in Kitivo District and Kiroka District, the basic conditions were promoted after the training (Table 5-5). In Ruanda Majenje, the good furrow and ridge were relatively we organized even before the training, leveling the field was improved but the rice planting in straight line was not popular. The images of good furrow and ridge and smooth rice paddy may vary the irrigation district to district. For example, the field compartment for rice paddy in Ruanda Majenje is narrow and small, and it has gradually changing to wider compartment (Table 5-5).

Table 5-5: Shift in introducing basic technology for rice cultivation in four irrigation districts (%)

	Year	Mussa Mwijanga, Kilimanjaro Region	Kitivo, Tanga Region	Kiroka, Morogoro Region	Ruanda Majenje, Mbeya Region
A	2008	50	10	0	40
	2012	75	50	< 50	50
B	2008	50	20	0	5
	2012	75	50	< 50	50
C	2008	100	40	10	1
	2012	100	100	90	< 5

(1) A: good ridge condition, B: leveled rice field, C: rice planting in straight lines

(2) The distance from KATC is about 20km (Mussa Mwijanga), about 200km (Kitivo), about 500km (Kiroka), and about 1,000km (Ruanda Majenje).

If we look at the breeds, the volume of fertilizer used and the volume of chaff in four irrigation districts based on the monitoring conducted at Tanrice, these are showing the characteristics of each district before and after the training (Table 5-6). In Musa Mwijanga District in Kilimanjaro Region, the breed (IR64) and the volume of fertilizer used (115kg N/ha) remained unchanged, but the yield of chaff increased. It is likely that refurbishing the irritation facilities (intake weir or so) impacted thereon. In Kitivo District in Tanga Region and Kiroka District in Morogoro Region, a new breed was introduced and the number of farmers who used fertilizer, the volume of fertilizer used and the volume of chaff were increased. In Ruanda Majenje District in Mbeya Region, the number of the farmers who used fertilizer decreased, and the volume of fertilizer increased and the yield was also increased a bit. In Ruanda Majenje, they are cultivating the existing breeds with high marketability and they are stick to its marketability (eating quality). In Musa Mwijanga District, people had already implementing dual cropping, but they started the dual cropping in Kitovo and Kiroka after completion of Tanrice training. According to “Research on Farmer to Farmer Extension Approach”, the method to promote the technology called Farmer to Farmer Extension Approach is functioning, and has been well-received by the farmers in the region, the promoters and the officers in the region. Farmer to Farmer Extension Approach under Tanrice is uniting the promoters and the core farmers. The core farmers participate in the group training at the agricultural training center together with the promoters, and the cooperative relationship between them is essential for technology promotion in the District, and the core farmers cooperating with the promoters are playing an important role for the general farmers. For the promoters, it is useful that the farm fields run by the core farmers are scattered (farm field for demonstration) for technical training. In addition, the agricultural workers was playing a role for promotion of the technology by using the technology and skills learned at the farm fields possessed by the core farmers and the middle-class farmers at the farm fields of other farmers.

Table 5-6: Rice breeds, fertilization and yield comparisons in four irrigation districts before and one-year after the training

Irrigated district (Region)	Training	Main breed	Fertilization (%)	Volume of fertilizer (kg N/ha)	Yield of chaff (t/ha)
Musa Mwijanga (Kilimanjaro)	Before	IR64 (70%), IR56, IR54, SARO 5	100	115	2.6
	After	IR64 (80%), IR56, SAR0 5	100	115	4.2
Kitivo (Tanga)	Before	SARO 5 (50%), IR56, IR54, TXD 220	20	28	2.9
	After	IR64 (70%), SARO 5, IR54	90	70	5.3
Kiroka (Morogoro)	Before	Supa Mbeya (40%), Rangi Mbili, Mbawa Mbili, Supa, SARO 5	10	9	2.4
	After	SARO 5, Supa Mbeya, Rangi Mbili, Wahiwahi, IR64	80	115	5.0
Ruanda Majenje (Mbeya)	Before	India Rangi Mkia (80%), Zambia, Rangi Mbili, Mwenda Mbio	20	29	3.4
	After	Rangi Mbili Mkia (95%)	5	58	3.8

Note: Some of the native breeds have the same name, but different breed.

Kitivo District in Tanga Region is one of the districts where the Tanrice training was very successful. Comparing the situation before and one-year after the training, we can see that selecting rice seeds in salty water, introducing reed-shaped rice nursery and planting in straight line were wide-spread. Tanrice training contributed to improvement not only in the yield of chaff but also the rate of payment for water usage (Table 5-7). Dual cropping was started in Kitivo and its area was expanded to about 150ha in 2009 and to about 170 ha in 2010. These achievements and the impact are the fruits of the great efforts made by the local government of Lushoto that won the budget for the training for Tanrice and the related parties in Kitivo District (the agriculture promoters, the officers at the organization managing the payment for water usage, the core farmers and the middle-class farmers) that conducted the training smoothly.

Under Tanrice, 1) the training on management of the irrigated district organizations upon recognition that the sustainability of the irrigated rice cultivation is secured by the proper maintenance of the irrigation facilities and operation of the irrigation districts, 2) the gender training in order to have and strengthen common understanding about the division of labor, profit sharing and decision making by gender in housekeeping, producing and processing agricultural crop (rice) and 3) the marketing training in order to share the awareness of role of and profit sharing with the farmers and the processing

companies and suppliers in improving the quality of rice were all conducted. In terms of the gender, they considered the ratio of participants in the trainings and the workshops should be balanced between men and women and encouraged to increase the ratio of women in the management team of the union managing the payment for water usage. The training by subject was conducted within five days in principle and that included the action plans and monitoring. For securing the sustainability in the districts where the yield of chaff increased by organizing the irrigation facilities and promoting the technology, the irrigation districts (six districts) where the training was conducted through LMIS, NIS and KATC Phase II Project were also taken care of through conducting the training by subject.

Table 5-7: Changes in rice cultivation in Kitivo irrigation district in Tanga Region

	Before the training (6/11/2008)	After the training (23/7/2009)	One year after the training (11/8/2010)
Rice cultivation area (ha)	141	205	270
Main breeds (%)	SARO 5 (50)	SARO 5 (50)	IR64 (70)
Seed selection in salty water (%)	0	1	98
Well Organized Bed for Rice nursery (%)	30	20	100
Rice field without furrow and ridge (%)	20	5	0
Rice field with good furrow and ridge (%)	10	85	60
Rice field where leveling is required (%)	80	15	40
Transplanting after 21-30 days (%)	70	20	90
Planting in straight lines (%)	40	80	90
Using push weeder (%)	0	10	25
Yield: (t/ha) general farmer	2.9	5.1	5.3
Low yield farmer	1.5	2.9	3.4
High yield farmer	4.8	6.8	7.3
Payment for water usage by farmers (%)	29	48	76

For NERICA training conducted in the second half of Tanrice, they recruited the development officer in charge of cattle farming in the Province, four promoters for farming in the village and 16 core farmers (4 per one promoter: in halves by gender). 20 kg of the seeds of NERICA was provided per the core farmer (5kg × 4 bags). The core farmers appointed three middle-class farmers jointly with the village promoters and the seeds were shared with the middle-class farmers. The core farmers were instructed to display NERICA in the place of about 0.1ha jointly with 3 middle-class farmers in accordance with the guideline for NERICA cultivation. The village promoters monitored the progress in the farm field displaying NERICA and reported it to Tanrice through the officer in charge of that Province. The environment in the dry-rice cultivation changed a lot throughout a year and there were many cases where the expected yield of chaff was not achieved, but the method they implemented through NERICA trainings was helpful for the irrigated rice cultivation trainings conducted later on.
In the Rice Promotion Support Plan Project (Tanrice 2: 2012–2018), the aim is to improve the productivity, marketability and sustainability of the rice cultivation across Tanzania (irrigation, dry

field. rain-fed lowland swamp) and they have been supporting consideration of the production technology and challenges (management of the irrigation districts, marketing for rice, the gender management) and strengthening the ability of the related parties (7 officers in charge of agriculture training, the officer in charge of agriculture and cattle farming in the province, the agriculture promoter and the farmers). “The joint training for the agriculture promoters and the farmers” initiated with KATC Plan has been gradually shifting to the trainings based on awareness of sharing roles and cooperation of labor among the officer in charge of agriculture and cattle farming in the province (making plan, evaluation), the village promoters (implementation and monitoring) and the core farmers (implementation).

The number of the agriculture promoters was cut during the transit period for adjusting the structure in the past, and in 2006 it was decided that the number of the agriculture promoters would be increased. Actually it has been increasing since 2009 or so. They are planning to allocate the agriculture promoters to about 13000 villages in the mainland of Tanzania, and it is essential to strengthen the ability of the promoters. The sustainability of the promotion of farm villages including rice cultivation would be secured if the agricultural training authorities mainly perform their primary tasks (long-term general training for the agriculture promoters before engagement and the short-term subject training after engagement) and each related authorities (the related parties) can play their own rules properly.

3) Collaboration with the irrigation development

Japan (JICA) cooperated for making the irrigation development master plan and the action plans across Tanzania through the development research called “National Irrigation Master Plan Research” (2001–2004). After that, they implemented the technical cooperation project called “Province Agriculture Development Plan (DADP) and Making Irrigation Business Guideline and Planning Trainings” (2007–2010) and they mainly supported 4 eligible irrigation zones in terms of 1) making “DADPs Comprehensive Irrigation Business Guideline” including management construction control, maintenance and training, 2) strengthening the ability of the office in the irrigation zone technically supporting implementation of the business in the province, and 3) strengthening the ability of the irrigation technical expert in the province to implement the irrigation business through the training provided by the office in the four irrigation zone. “Plan for Strengthening the Ability for the Province Agriculture Development Plan (DADP) Irrigation Business Promotion” (2010–2014) has continued to be implemented, and they have supported strengthening the ability of the related parties in order to implement the irrigation business across Tanzania in accordance with the guideline.

Mahande District in Arusha Region and Mbarangwe District in Morogoro Region were the eligible districts to making Tanrice and DADP irrigation business guideline/training plan. In Mahande District (275 farmers, the irrigation area 142ha), the training was conducted by KATC (2007–2008), and after that, the irrigation facilities were refurbished. The yield of chaff in Mahande District was 1.6t/ha

(2007) before the training but, increased after the training to 2.9t/ha (2009), 4.9t/ha (2010) and decreased to 3.9t/ha (2011). In Mbarangwe District (76 farmers, the rice cultivation area 72ha), the training was conducted by Ilonga Agriculture Institute (2010) after completion of constructing the irrigation facilities, and then the yield of chaff increased to 4.5t/ha after the training (2011), comparing to 1.3t/ha before the training. In Mahande, the furrow and ridge as well as transplanting were introduced, but the training contributed to progress in field leveling and proper seasonal operations. In Mbarangwe, they did not introduce furrow and ridge yet and cultivated in rain-fed direct seeded cultivation (scattering-seeded), but they introduced furrow and ridges and transplant production.

In Japan, they provided the cooperative support to Coast Region (technical cooperation with Bagamoyo Province) and Morogoro Region (free financial cooperation for Mwega irrigation business) for promoting rice cultivation. In 2013, a contract for loan aid cooperation project was signed for "the Small-scaled Irrigation Development Business " and thereby cooperation for constructing new irrigation facilities, refurbishing the existing irrigation facilities and procuring the related equipment was agreed in order to expand the irrigation area. Also a part of fertilizers provided by 2KR was distributed to the farmers in the irrigated areas, and a part of its remuneration was used for constructing and refurbishing the irrigation facilities and providing the trainings for the related parties. Experts were sent to Arusha Industrial University in order to cooperate for designing develop irrigation development, constructing and maintaining the irrigated farm field and facilities and training human resources for water management.

6. Development Trend of Rice Cultivation in Tanzania

1) Rice-Getting popular

They eat a variety of crops (grains, root vegetables, banana) in Tanzania as staple food and the main grain is corn. In 1960s, sorghum and millet followed corn, but recently the production volume of rice has significantly increased to become the second largest grains harvested in Tanzania. On the other hand, the production volume of millet and cassava has not increased so much (Table 5-8).

The quality and eating quality of rice produced in Tanzania varies and the consumers in town areas are so sensitive in terms of the quality, eating quality and the price. The existing breed (especially Supa and similar breeds) has good aromatic characteristics, and is traded at higher price. Rice produced in Kyela in Mbeya Region is transported not only to Dar es Salaam but also to Zanzibar where suffered lack of rice and to northern part of Tanzania. They are traded at high price than that of general imported rice. As for improved variety, SARO 5, aromatic rice, is drawing attention.

Table5-8: Production Volume of Main Crop in Tanzania (average/last 10 years) and Changes over the last 40 years

	1961–70	1971–80	1981–90	1991–00	2001–10	Change
Rice (chaff): Harvest area (ha)	109,100	207,882	305,162	417,747	693,707	6.36
Production volume (t)	120,605	274,700	491,846	661,047	1,312,887	10.89
Yield (kg/ha)	1,134	1,358	1,587	1,603	1,892	1.67
Maize: Harvest area (ha)	957,300	1,178,490	1,588,954	1,535,861	2,747,417	2.87
Production volume (t)	681,800	1,237,900	2,165,800	2,292,476	3,804,018	5.58
Yield (kg/ha)	750	1,025	1,362	1,572	1,571	2.09
Sorghum: Harvest area (ha)	345,700	516,375	530,645	655,805	685,468	1.98
Production volume (t)	160,249	326,892	527,381	636,838	664,653	4.15
Yield (kg/ha)	708	609	1,064	972	954	1.35
Millet: Harvest area (ha)	188,500	290,000	287,243	267,255	288,645	1.53
Production volume (t)	130,883	231,708	300,812	245,533	225,592	1.72
Yield (kg/ha)	697	774	1,108	931	778	1.12
Wheat: Harvest area (ha)	30,700	57,498	48,099	58,651	55,495	1.81
Production volume (t)	32,368	75,000	80,464	73,000	78,990	2.44
Yield (kg/ha)	1,038	1,386	1,675	1,285	1,767	1.70

Source：FAOSTAT

The import volume of rice in Tanzania is larger than the export volume of rice, but the export volume of rice is on upward trend and the rice produced in Tanzania is well received in the neighboring countries. In Tanzania, the Government imposes a ban on export of grains in case of food shortage. Therefore the farmers in the main rice producing areas and in the main corn producing areas as well as the governments of the neighboring countries are unhappy about it.

In Moshi and Arusha, rice called Japani (meaning Japan) is sold that is produced in LMIS and other neighboring countries. Comparing to Kyela rice and Morogoro rice, its price is lower, but the distance between the place of production and the place of consumption is short and the price of chaff at farmer's gate in Kilimanjaro Region (Lower Moshi) is higher than that in Mbeya Region (Kyela). In northern part of Tanzania (Kilimanjaro Region, Arusha Region, Tanga Region), rice is running short and these areas are adjoining to Kenya, the rice importing country. Therefore, the rice cultivation mainly in

Lower Moshi, Kilimanjaro Region (northern part of Tanzania) is expected to grow in terms of production technology and its processing and distribution.

2) **Direction of Rice Development**

In general, the rice cultivation in Tanzania is sorted out to rain-fed lowland swamp rice and wet-land rice (irrigated rice) (Table 5-9). According to the National Rice Development Strategy announced in 2009, the rice cultivation area in Tanzania is estimated to be 681,000ha (dry rice: 17,000ha (2.5%), rain-fed rice in lowland swamp: 464,000ha (68%), wet-land rice: 200,000ha (29%)). Also it is estimated that about 72% of the rice cultivation area in Tanzania (510,000ha) is lowland swamp and 8% to 10% is paddy field.

Table 5-9: 10-year plan to increase rice production in Tanzania

	Dry land			Rain-fed lowland swamp			Irrigated rice plant			Total		
	Area	Yield	Production volume	Area	Yield	Production volume	Area	Yield	Production volume	Area	Yield	Production volume
2008	17	0.5	9	464	1.0	464	200	2.13	426	681	1.3	899
2013	21	1.0	21	374	1.5	561	290	3.0	870	685	2.1	1,452
2018	31	1.6	50	274	2.0	548	390	3.5	1365	695	2.8	1,963

Note: Cultivation area (1000ha), yield of chaff (t/ha), production volume of chaff (1000t)

Source: Tanzania National Rice Development Strategy Final Draft, May 2009

Development scheme by the Government of Tanzania is agriculture-oriented and includes promotion of irrigation. The Government is active in developing new irrigation facilities and refurbishing the existing facilities, and the farmers are active in opening rain-fed lowland swamp field suitable to rice cultivation. Part of rain-fed lowland swamp (rain-fed rice paddy) will be changed to irrigated rice field (rice paddy) and new rain-fed rice paddy will be developed, too.

NERICA is resistant against drought and early rice breed, meaning that it may spread into areas not proper for rice cultivation (lack of rain, slope, etc.). NERICA has been spreading into the rain-fed lowland swamp (for example, Ngage Province in Tabora Region) and will draw attention as relatively resistant against stress (drought, diseases).

On the other hand, in the areas where changes in the weather impact significantly, the areas for rice cultivation and rain-fed rice cultivation are decreasing. For example, the quantity of water in River Lao running through Moshi has been decreasing significantly over the last 20 years. The yield of Segera's dry rice cultivated in Korogwe Province in Tanga Region, located almost midway between

Dar es Salaam and Moshi (in some years, rain-fed lowland swamp rice) was almost zero for five years between 2007 and 2012 due to drought.

For sustainable development of the irrigated rice cultivation and the rain-fed lowland swamp rice cultivation, maintaining the proper conditions in upriver of water source and managing irrigated water and surface water properly will be important factors. As for promotion of dry rice, we need to pay attention to the slopes in the dry fields and take actions to avoid runoff of earth and sand. Important thing is how we can improve the productivity and the quality of rice while reducing environmental load, rather than how much % we can expand the crop cultivation areas out of the cultivatable lands.

3) Farm Tools and Agricultural Machines

Farm tools and agricultural machines are developed and introduced in order not only to economically conduct agricultural operations at proper timing at high task accuracy but also to reduce heavy labor. In Tanzania, hoe, sickle and chopper (panga) are common and other farm tools and agricultural machines are not so popular.

In most of the irrigation areas in Tanzania, their main means are human power (using hoe) for preparing furrow and ridge, plowing, puddling, and leveling the field (Table 5-10). Among 32 irrigation areas where Tanrice did interviews, only man power was used in ten areas (28%) and man power was used for 66%–99% of the total plowed and puddled fields in eleven areas.

Plowing by using cattle was done in more than 2/3 of the total area in Mahiga (100%) and Sawenge (88%) in Mwanza Region, Uwachero (95%) in Mara Region, Kasybone-Kisegese (90%) and Mshewe (70%) in Mbeya Region, Mfumbi (80%) in Iringa Region. Tillers were used in Ngage (75%) in Manyara Region, Mahande (50%) in Arusha Region, Musa Mwijanga (40%) in Kilimanjaro Region, Uturo (25%) in Mbeya Region, Mfumbi (15%) in Iringa Region and Mvumi (15%) in Morogoro Region. Tractors are not so much used except Kitivo (90%) in Tanga Region and Kibokwa (20%) in Zanzibar Island.

In about half of the irrigated area, puddling and leveling have been done only by man power. Comparing to plowing, it is much less, but in Mahiga (75%) in Mwanza Region and Uturo (20%) in Mbeya Region, puddling and leveling using cattle was popular. Puddling and leveling using tiller was popular in Ngage (75%) in Manyara Region, Mfumbi (70%) in Iringa Region, Mahande (50%) in Arusha Region, Musa Mwijanga (40%) in Kilimanjaro Region, Kwemgiriti and Kituani Mwezae (20%) in Tanga Region, Uturo (20%) in Mbeya Region, Kibokwa (20%) in Zanzibar Island, Ilonga (15%) and Mvumi (15%) in Morogoro Region (15%). They did not use tractor for leveling.

Table 5-10: Comparison of first plowing, puddling and leveling of the field in irrigation area

	First plowing (33 districts)				Puddling and leveling (32 districts)			
	Manpower	Cattle	Tiller	Tractor	Manpower	Cattle	Tiller	Tractor
100%	27.3	3.0	0.0	0.0	50.0	0.0	0.0	0.0
99–67%	33.3	15.2	3.0	3.0	31.3	3.1	6.3	0.0
66–33%	12.1	6.1	6.1	0.0	9.4	0.0	6.3	0.0
32–1%	21.2	27.3	27.3	21.2	9.4	15.6	25.0	0.0
0%	6.1	48.5	63.6	75.8	0.0	81.3	62.5	100.0
Total	100	100	100	100	100	100	100	100

Note: Lower Moshi irrigation area and Ndungu irrigation area are not included in the irrigated area. They did rain-fed direct seeding in one district, and they did not do puddling and leveling.

In LMIS, plowing using tractor (using rotary in dry field) and puddling and leveling (using drive harrow under submerged condition) have been implemented since 1980s, but in late years, only puddling the field have been implemented (using rotary under submerged condition). The number of tractors decreased, and puddling the field have been implemented using tiller and man power in a certain areas.

The Government of Tanzania has provided the training for the operators and the operators in charge of mechanization of the agricultural machines by using the tractors and tillers provided through technical cooperation. Setting the first priority on agriculture, the Government of Tanzania has instructed each province to procure the agricultural machines (especially tillers) and distribute them to the farmer organizations, and in KATC they have been entrusted with training on the agricultural machines from the Government and the provinces. In order to promote the agricultural machines, its maintenance is important challenge. KATC has been recognized as training center related to tractor and tiller in Tanzania, and the needs not only to learn its operations but also to learn how to repair it will increase. Big surge toward the mechanization in agriculture can be seen, but they need to solve some issues in order to secure its sustainability.

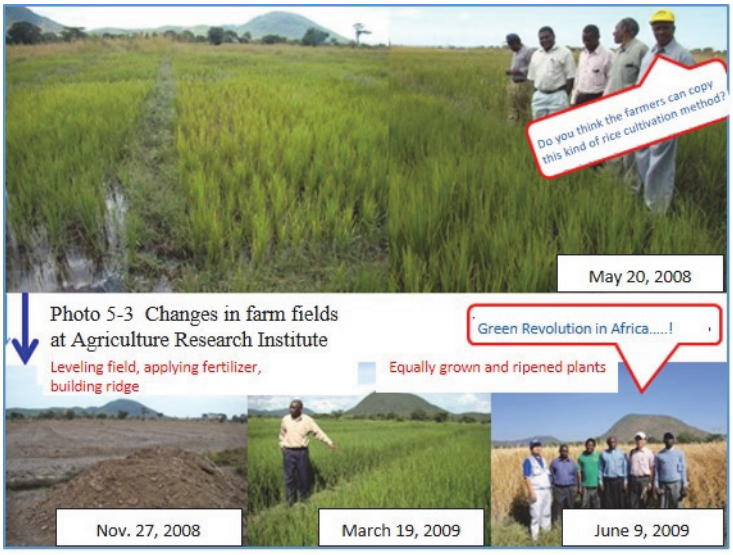
In KATC, agricultural tool for leveling, push weeder, grain beating table were produced. Especially by the push weeder, the male farmers have taken interest in weeding and weeding is becoming popular in some irrigated areas. In order to reduce agricultural labor, not only introducing the agricultural machines but also improving the farm tools is meaningful. Preliminary plowing, plowing, puddling, leveling, weeding, harvesting, operations after harvesting are all heavy labor works, and it is expected so much that a farm tool and a method of farming would be developed and improved in order to release people from agricultural heavy labor.

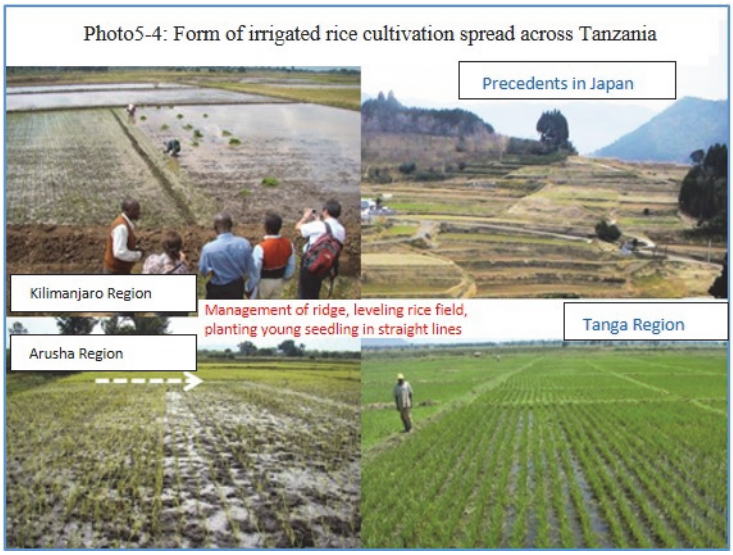
7. Conclusion

By an initiative to increase the volume of rice in Asia (it is called, “Green Revolution” started at the end of 1960s, the irrigation, breeds, fertilizer and pesticide contributed to improving the productivity. The production volume of rice increased at that time in Tanzania mainly due to expansion in area, so that the productivity remained unchanged.

In LMIS, constructed in 1987, water was distributed, plowing, puddling and leveling were implemented under guidance by KADP, and rice seedling growing in the group rice nursery was transplanted at proper timing, and harvested, thrashed and dried chaff were milled by a large-scale rice mill. High yield rice cultivation in LMIS was achieved in a form of the irrigated rice cultivation (in a surface smoothed rice paddy surrounded by furrow and ridge). Rice cultivation in LMIS achieved improvement in its productivity, but there still remain some challenges in managing water source and operating the irrigation area.

Form of rice cultivation as essential factor in LMIS and KADP was succeeded by KATC, and the abilities at other agricultural institutes have been strengthened (Photo 5-3). The principal in the irrigation rice cultivation is the same as in Japan (Asia) and in Tanzania (Africa).





The succeeded form of the irrigated rice cultivation has been settled down in each districts in Kilimanjaro Region, Arusha Region (Lekitatu and Mahande), Tanga Region (Mombo and Kitivo), Morogoro Region (Mkindo and Kiroka), Mbeya Region (Mbuyuni), Ruvuma Region (Mahiga), Zanzibar Island (Mtwango) and so on, and spread into other irrigated areas (Photo 5-4). Together with the form of the irrigated rice cultivation, planting in straight lines gradually can be seen in many areas in Tanzania, and also dual cropping,

early season cultivar (Wahiwahi and NERICA 1) and push weeder have spread into a certain areas as example to show the impact by the cooperation in the rice cultivation promotion.

The cooperation in the rice cultivation promotion after the period to adjust the agricultural structure in Tanzania, since the core farmers actively participated in the activity and the productivity was improved to some extent even during the period where the number of the farmer promoters reduced or the budget was cut. The core farmers and the middle-class farmers who participated in the training together with the promoters demonstrated that the yield would increase if the irrigated water, technology, skill, materials and equipment were introduced to the rice paddy in the form of the irrigated rice cultivation. The promoters and the farmers became to have knowledge about the rice cultivation as well as they put them into practice, and therefore the general farmers gradually become to be able to cultivate equally grown and ripened rice plants (for example, Kitivo in Tanga Region).

By the rapid increase in rice price internationally in 2008, the Government of Tanzania recognized the importance to produce rice for its own country and the possibility to export rice. The Government of Tanzania has been putting the first priority on the agriculture, promoting the irrigation, increasing the agriculture promoters, introducing the input (fertilizer) assistance scheme (Voucher System), promoting machines and equipment into the agriculture, introducing Saving and Credit Cooperative Society (SACCOS) and Warehouse Receipt System and promoting the private sector investment, and furthermore, practicing the large-scale rice cultivation promotion business such as Southern Agricultural Growth Corridor (SAGOT).

The Government of Japan has supported promotion of the rice cultivation in Tanzania since 1970s, and recently, World Bank, USAID, IFAD, International Agriculture Research Institute (IRRI, AfricaRice), the emerging supporting countries (South Korea, China, India), NGO (Oxfam, Aga Khan, BRAC) and Japanese companies (consultants, agricultural machine makers), research institutes, universities, NGO and so on are all drawing increasing attention. We hope these activities are contributing to improving the living standard of the rice cultivation farmers, development in the rice cultivation farms and stable rice supply to the citizens in Tanzania.

It is important to maintain the irrigation facilities and manage the irrigated water in order to increase and stabilize the yield of the irrigated rice cultivation. For that purpose, it should be encouraged that people have initiatives to establish standards, keep awareness and take actions based on a concept “the irrigation facilities should be maintained voluntarily and continuously by its beneficiaries” (Photo 5-5). In order to harmonize with the limited water resources, technology development, trainings and promotions should be encouraged as well, leading to water-saving type of irrigation at scheme and

plot levels. While referring to the experiences in Japan and Asia, it is worth sharing the cases seen in Tanzania and Africa.

Photo 5-5: Securing sustainability in irrigated rice cultivation