FRG II Project

Empowering Farmers' Innovation

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Experience in Rice Mechanization

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Ethiopian Institute of Agricultural Research

Experience in Rice Mechanization

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About FRG II

THE PROJECT FOR Enhancing Development and Dissemination of Agricultural Innovations through Farmer Research Groups (FRG II Project) is to enhance the capacity of researchers to take part in innovations through farmer research group approach (FRG approach). Implemented by a technical cooperation between Ethiopian Institute of Agricultural Research (EIAR) and Japan International Cooperation Agency (JICA), the FRG II covers all the agricultural research institutions in the country through training on the approach, financing FRG based research projects in selected priority research areas and filling gaps and enhance linkages between research and extension by delivery of technical information. For more information, visit

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Experience of Rice Value Chain Project in Amhara Region

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Introduction

Ethiopians Driving Growth through Entrepreneurship and Trade (EDGET) is a five-year (January 2011-December 2015) rice value chain development project, aimed at increasing incomes of 8,000 rice farmers by facilitating access to growing markets, enhanced production techniques, appropriate technologies, improved input supplies, and affordable support services including finance. The extensive market research made by Mennonite Economic Development Associates (MEDA) in the Ethiopian rice sub-sector, lead to the selections of potential rice growing areas of Libokemkem and Fogera woredas in Amhara Region and Gurafarda woreda in SNNPR for the rice value chain project called EDGET. The value chain assessment in the target project woredas revealed that chain actors in the rice subsector did not have the means and tools to solve the common problems that affected their business in the sector.

Business relations between farmers and the processors/millers and other supporting agencies are fragile. These relations border around suspicions. It is characterized by actors pointing fingers at each other in a 'blame game'. The farmers claim that the processors/millers do not reward them for their production investments. They pay prices that are not enough for farmers to make a return on their investments. The farmers felt exploited. On the other hand, the rice buyers bemoan that the farmers fail to supply quality products in sufficient quantities. They ask for high prices that make business unprofitable. The farmers do not understand the processes that occur from production up to the final consumer. All these factors create mistrust among chain actors.

Service delivery agencies, research institutes, NGOs working in the sector, business service providers, donors, etc have not created synergy to improve relationship among chain actors along the chain. The

smallholder farmers depended on market information that is limited and sometimes unreliable. Support agencies discharge service through conventional approach that does not link to the specific impact areas or to the market requirements. In general, there is no common understanding hence lacks a concerted effort to work towards the same goal.

EDGET Project has attempted to facilitate for working out the solutions to the problems of rice sector development and ensure sustainable growth. Major interventions were focused in the production side at the producer level and at the marketing side, which supports actors at the intermediary and processor level. In order to increase sustainability and impact, the project has focused on building the capacity of chain actors that enhances sustainable market linkage through business-to-business relationship.

Rice production in the Amhara project area is currently dominated by smallholders who produce rice for home consumption and sell surplus directly to processors or cooperatives. According to the local government offices, about 35,300 smallholders are engaged in rice production with average land size of 0.58 ha per household with a potential production of 85,990 tons of rice. Since the start of EDGET project intervention in 2011, the number of smallholders engaged in rice production has been increasing. They reported yield increases and productivity mainly catalyzed by upgrading of skills, knowledge, access to improved seeds and better market values. Farmers normally sell their rice at farm gate, at the local processing center, or to traders and cooperatives. Smallholders noted that they could have better price had they sold in aggregate markets. Farmers normally use traditional farming methods, as many have not received any extension services. However, during the project implementation, smallholders used improved practice such as seed soaking, row planting, transplanting, use of weeders and airtight bags to improve post-harvest handling.

Project Implementation Approach

The EDGET project follows a three layer value chain approach that encompasses **chain operators** (input suppliers, producers, collectors /processors, wholesalers, retailers and consumers), **chain supporters** (service delivery agency, NGO's, business service providers, researchers/universities), **Chain enablers** (policy makers, working context, rules and regulations, terms of trade).

MEDA believes that the interconnection between those actors can produces quality products. A quality product could be produced by the stakeholders through full range of functions needed to take a product from its producers to its end consumers, through different technical stages (including production, marketing, distribution, and support). The quality of the products depends on the involvement and interrelationships of those actors.

Based on the above working philosophy, the project intervention framework is designed to improve the performance and income of smallholder rice farmers in the project area. The model applied to facilitate the implementation at the producer and intermediary level is processor-lead-farmer business model. This model improves sector development that enhances agronomic skills and knowledge of producers and processors this then creates opportunity. The second model that connects processors to other buyers like wholesaler /retailers enhances the business-to-business relationship and turns opportunities into results. The multi-stakeholder platform tools bring all together to make a dialogue that ensures trust and confidence between all actors through win-win relationship. When actors come together, it makes things easy and fast to draw lessons from the existing knowledge base. The forum creates a space for innovation and synergy among different actors to improve the situations that enhance the sector development and business relationships. This chart shows the basic maps of rice value chain in the target areas. The map helps to:

- understand the actors relationship at segment;
- assist us to communicate well internal and external;
- identify actors, roles and relationships;
- identify best market segments and product flows; and
- identify trends and dynamics that helps to solve issues that affect their relationships

During the implementation process, the project is attempting to address the following principles

High Impact

- The smallholder farmers should accessing markets as sellers;
- Reaches many farmers (Depth of impact) as planned ; and

- The intervention reaches "under-served" groups. It helps rice growers increase incomes as they grow, prosper & reach markets (Breadth of impact)

Focused

- The intervention focuses on removing constraints/barriers that prohibit rice growers from participating in higher value markets; and
- The interventions strengthen each segments of the chain and solves problems of market relationship

Market Driven

- Intervention focuses on the 'demand' sides or end consumers of rice products;
- Intervention focuses on markets that reach higher value markets for rice growers to participate; and
- Markets are dynamic; they often change in response to opportunities and developments

Sustainable

- Market actors continue working together when the EDGT project phases out from the area.
- Support markets provide needed services to strengthen market systems
- Business support services are provided in a financially viable way

Respect the value chain boundaries – respect no flying zone

- Stay outside the chain operators zone – don't interfere rather facilitate and greasing the chain segment to operate very well
- Remember that Value chain solutions can come out of internal /or chain operators (embedded services, effective horizontal and vertical integration)
- Always identify points of leverage within the VC
- In case of missing functions, kindly note that Chain supporters can opt to facilitate the development of these functions (e.g sales agents, seed and input supplier dealers, designers). This is sometimes done through strategic business incentives
- Nothing is static with value chain; most interventions normally take a learning curve accompanied with reviews and refinements

Results of the Major Interventions

The key component of the project is strengthening the push side **(production) and pull** side **(Marketing)** to improve the efficiency and effectiveness of the sector. The key intervention areas are:

- Ensuring all actors have awareness on the approach and modalities of project intervention;
- Improving producers pre-harvesting and post-harvest practices (Good agronomic practice, timely harvesting, using tarpaulins for harvesting, not mixing varieties);
- Facilitating processor and other SMEs have access to credit services to purchase new equipment and other facilities to improve the sector;
- Improving sorting and grading practices for rice processors;
- Promoting access to information for Ethiopian low and middle-income consumers about local rice through promotional campaigns ; and
- Creating market linkages for input firms offering rice-specific inputs.

Project clients targeting, orientation, and familiarization

Client selection process has been facilitated by ad hoc committees that encompass village administration, development agents, and representatives from the elder, youth and women associations. Additionally, recruitment of lead farmer by the rice millers in other words, selection of client farmers has been done by processors directly without the involvement of other external body. Both methods have advantage and some degree of bias and the later was found to be an excellent method to enhance the market linkage between producers and rice processors. A 'client registration' format was if brought up basic profile of the client farmers. It included data like age, sex, marital status, land holding, family size, and place of residence. Following client selection, groups were formed and those client farmers were clustered into functional extension groups.

The project is performing very well based on its targeted number of clients. The total number of clients registered in the two and half years of the project life reached 5,095 (790 female clients) requiring only 1405 farmers to be registered in years 4 and 5 in order to reach the 6500 target over the project's five-year period. Based on the current momentum, MEDA is likely to exceed this target.

This component of the project supports familiarizations of stakeholders to build shared visions on the project implementation modalities. Facilitating client selection and organizing farmers into functional extension groups (1:5 one lead farmer to support other 4/5 followers) has resulted in organizing 1031 cluster groups in 12 target kebeles.

Farmers have access to improved technology and Extension services

Farmers have access to improved seed

Different improved seed access and delivery systems have been tested. In the first year of the project, the private sector led the seed extension system was tested. However, the private sector declined in the second year of the project, because of the cereal crop based business venture was not found profitable. The public seed enterprise company (Amhara Seed Enterprise) tried in the second year of the project, but did not succeed even in its own seed multiplication sites. Learning from the two experiences, the project on seed multiplication concentrated within organized farmers group.

So far, improved seeds have been distributed in the following ways:

- In the first year of the project, the private firm accessed 50q of NERICA 4 basic seed from Adet Research Center. Through the use of smart subsidy (40%) as a tool, around 107 project client farmers got access to the new varieties; 27.5 ha of land was covered anticipating a production of 825 q, which was agreed to be sold for the private sector at 15% premium price against the local market price. However, not all the assumptions worked, farmers loved the seed, they deviated from the agreement they made with the private sector and refrained from giving back the seed to the enterprise. As a result, the private seed enterprise collected only 70 q of rice seed out of 825 q. In spite of all investments made at year one using private seed model system, the result was not satisfactory particularly from the business angle to continue. Then the private sector ended its engagement upon the distribution of 49.5 q of Nerica 4 with a 30% price discount;
- In the third year of the project, Adet Research Center, a partner of the EDGET project, supplied 35 qs of the EDGET variety (new rice varieties released by Adet in 2011) and 15 qs of the Nerica4 seed to 8 seed multiplier clusters, comprising of 195 farmers (14 female). Jointly with Adet Research Center, seed multipliers have received training and technical back up for the productions of clean seed. Upon the production of this

paper, seed multipliers groups were under discussion with the Ethiopian Seed Enterprise and cooperatives to sell the produced seeds; and

- Additionally, MEDA facilitated farmer-to-farmer seed exchange for improved X-Jigna and Nerica 4 seed varieties. As a result, 192 qs X-Jigna and 250 qs of Nerica 4 seed was exchanged among 229 famers.

Build farmers capacity to improve agronomic practices

With the aim of enhancing farmers skill in rice production, capacity building training on rice agronomy was provided to 1,722 cluster led farmers. The cluster leaders in return deliver the training into the follower farmers. The project extension workers practiclly monitor the applications of the acquired skills and knowledge. Each cluster meets every fortinghts on the selected fields to exchange lessons learned and record conculusions. As a result, more than 50% of EDGET client farmers improved their agronomy practice by applying row planting (2689 clinets), seed sokaing/pr-germination (2490 clinets), transplanting (67 clinets), fertilizer application (2300 clinets),constructing new soil bunds to effectuate water management (1161 clients) and using of rotary weeders (127 pieces)

To accelerate learning, 12 Farmer Field Schools (FFS) were established, with an average member of 20-25 farmers per FFS, this helped the clients for innovations and promoting appropriate agronomic practices among farmers. Moreover, the distributions of good agronomy fact sheets for all lead farmer's stimulated learning based on scientific references. In addition, experience-sharing visit on farmer's day was an important tool to speed up the disseminations of good agricultural practice including row planting, timey weed management, use of improved varieties, seed soaking, and fertilizer application among farmers.

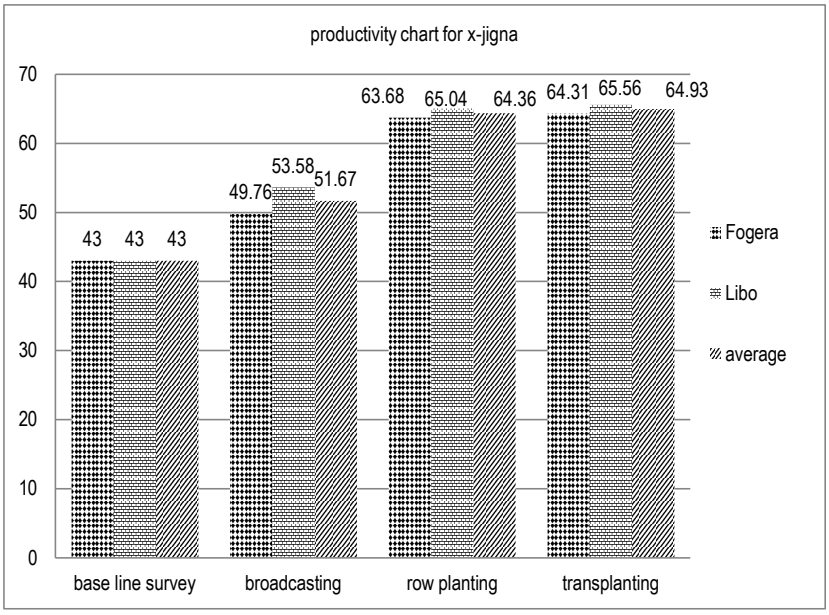
Demonstrating and scaling up of pre- and post-harvest technologies

The project has catalyzed the demonstration of various technologies that could maximize production and productivity of rice. Among the demonstrated technologies rice harvester, weeders, airtight super bags, and tractor were accepted for wider use within the rice producers. Following the demonstration, 127 different types of rotary weeders (up land and low land) were distributed to client farmers through a 70% price smart subsidy. Moreover, a contract agreement was signed with a private company to import and distribute 10 rice harvesters to client farmers at a 50% smart discount. Arrangement is also made to avail hermetic plastic bag to client farmers at a 50% discount price for the first 10,000 batches.

Indicators of yield increase

The popularization, demonstration, promotion, and creating access to those technologies coupled with good agricultural practice have shown progress on the increase of yields. A snap shot sample yield survey analysis has been conducted in 45 farmers in 9 project targeted *kebeles.* The study compared yield difference between broadcasting vs row planting and row planting vs transplanting. The yield data analysis indicates an average yield increase of 51.67 q/ha from 114 broadcast sampling for X-Jigna (widely used local variety). This productivity increase compared to the baseline survey conducted early in 2011 (43 q) has a difference of 8.67 q/ha or (20%). In the case of row planting from 84 samples an average productivity of 64.36 q/ha was recorded, this compared with the current broadcasting (51.67 q/ha) has a difference of 12.69 q or 24.56% increase while transplanting compared with broadcasting and row planting has shown yield advantage of 13.26 and 0.57 q/ha respectively.

The yield difference between row planting and transplanting was insignificant although transplanting has less weeding requirement than row planting. This is because of repeated plowing and the seedling has a strong capacity to depress the newly emerged weeds. In some cases within the same planting methods, high variations of yield have been observed from kebele-to-kebele. This pronounced yield variation was attained because of the suitable features (slope) of the land. The lowland plain got adequate water supply and accumulations of loam soil from the highland catchment through erosion, which created the suitable environment for maximized rice yield. Those yield samples were rejected to avoid exaggerated yield increment difference. In general, this snap shot yield survey illustrates that row planting and transplanting methods of rice have yield advantages over the traditional practice of broadcasting. Sampled production chart taken from 45 farmer field in 2013 harvesting season (production in q)



Processors have access to equipment y

One of the critical constraints in developing rice value chain constraints are processing of low quality rice. These resulted from poor pre and post-harvest handling of rice by producers and processors. Processors are using relatively less advanced / one- pass rice processing equipment. Despite the great attempt to improve the quality of paddy rice produced by farmers through MEDA's different interventions in rice VC development; upgrading rice processing by available better technology remains still unaddressed though it is critical for improving quality of rice produced, processed and marketed from the Region.

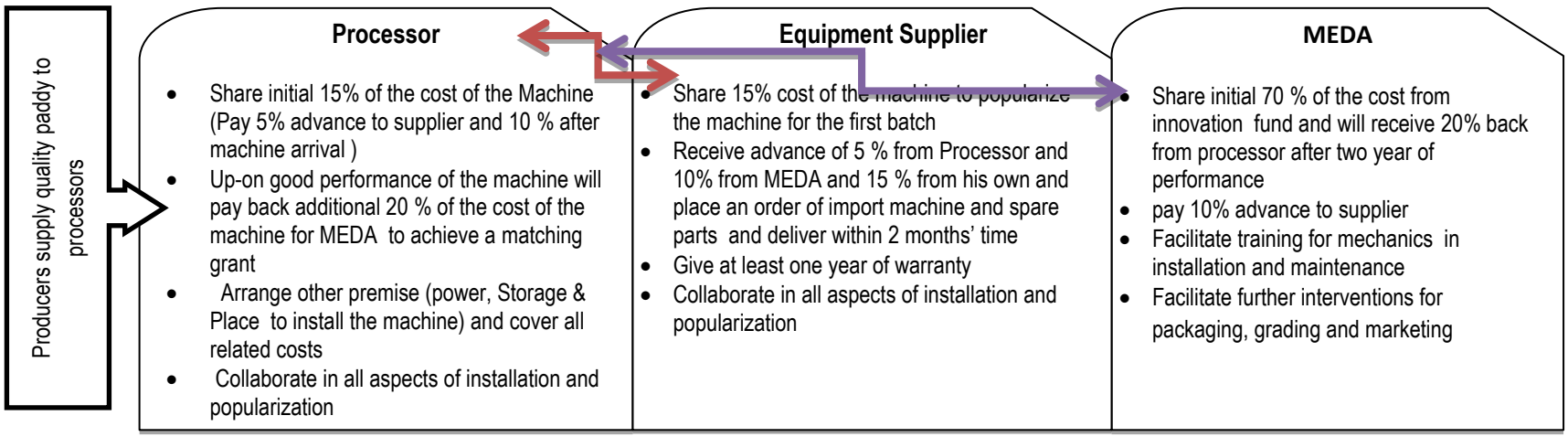
Hence, the need for upgrading rice processing by a combined machine enables the processors to have better quality output rice with different grades. This will further enable them to segment their market according to the grade and quality of rice they are producing to supply from the local to central market.

Acquisition of a combined machine by processor was difficult due to high investment requirement. Therefore, an integrated Processor-Supplier-MEDA framework was set to solve the problem. Below was a methodology employed for acquisition of the combined machine to accelerate investment in machines.

The model allowed installation of two new combined machines into the

two project sites, which has pre-cleaning, hulling, and sorting functions. Training on machine operation was given to 18 machine operators and processors. Currently, the machine is under operation.

Furthermore, to improve the quality of rice, processors were supported with parboiled equipment that reduce breakage and improves the nutritional value of milled rice. As a result, a contract was given for a local manufacturer in order to provide ten electric parboiled machines, each with a 50 kg capacity. This parboiling equipment was demonstrated to processors, who are interested in supplying parboiled rice to the market. So far, eight interested processors have taken the equipment with 50% cost sharing. Moreover, clay pots, which can be used to paraboil rice at the household level have been demonstrated to 599 farmers (160 women.) The demonstration had an immediate impact by stimulating processor to buy 14 units of clay pots to be used for parboling and distributed them to interetsed women to supply parboiled rice to the processor.


Producers supply quality paddy to processors
Processor
Share initial 15% of the cost of the Machine (Pay 5% advance to supplier and 10 % after machine arrival)
Up-on good performance of the machine will pay back additional 20 % of the cost of the machine for MEDA to achieve a matching grant
Arrange other premise (power, Storage & Place to install the machine) and cover all related costs
Collaborate in all aspects of installation and popularization
Equipment Supplier
Share 15% cost of the machine to popularize the machine for the first batch
Receive advance of 5 % from Processor and 10% from MEDA and 15 % from his own and place an order of import machine and spare parts and deliver within 2 months' time
Give at least one year of warranty
Collaborate in all aspects of installation and popularization
MEDA
Share initial 70 % of the cost from innovation fund and will receive 20% back from processor after two year of performance
pay 10% advance to supplier
Facilitate training for mechanics in installation and maintenance
Facilitate further interventions for packaging, grading and marketing

Consumers have access to information about the local rice to increase demand and improve the market value through market linkage

Low quality rice and poor market linkages were critical problems to the promotions of local rice into the higher end market.

Processors are supported to promote local rice through trade fairs and exhibitions that greatly increased the demand of local rice. Use of nutritional fact sheets, brochures, recipe leaflets has increased the positive images of the rice produced by the target areas. This in turn created shared understanding among the processers about what the market required. As a result, some processors and women group have started to produce good quality brown and parboiled rice that enables them to enter into a niche market at Addis super markets. An export and import trading company called Endoto has packed local rice with the name ***'ADDIS RICE'*** and is currently able to retail through supermarkets in Addis Ababa.

Name of supermarkets	Area
Friendship	Bole
Olive	Gerji
All mart	Gerji
Safeway	CMC
Lomyad	CMC
Shi Abebayehu	Gurd Shola
Belonias	CMC
Abadir	Gurd shola
Addis	Gurd shola
Bambis	Kazanchis
Amigo	Gergi
Negash	Sarbet
Save more	Old air port

Labeled and packed Addis rice retailed in Addis super market

Most paddy rice is sold at commoditized pricing without any differentiation in quality as measured by varietal purity, physical cleanliness, or moisture content so that it can be processed efficiently. The project proposed a voucher scheme to demonstrate to both farmers and processors that quality matters and can be the differentiating factor in increasing their income. This is predicated on the assumption that markets downstream exist or will be created downstream that are willing to pay a premium for rice of a higher quality. On top of the above lists, final moisture content test by the processor and confirmed by the marketing committees will results in Grade 1, Grade 2 or non-graded for those that do not meet either of the standards. The project provided rice moisture test with cost sharing by farmers.

This practice will show for the processors to the value of paying premium price and would change the purchasing pattern in successive years to promote a tiered pricing program that continues to reward farmers for providing higher quality rice.

To improver post-harvest management, the project has also assisted High Tech Plc to provide airtight bags that protects rice from insects and pests during the handling process. This is also supported through cost sharing mechanism. The aggregate marketing storage construction is also the same practice to stimulate producers improve the quality of rice just after harvesting.

Supported value chain actors have access to improve financial services

Weak financial literacy, Inherent level of risk, lack of saving habits, fears of accessing formal credit, mistrusting of the formal group-method of accessing finance from Micro finance institutions were some of the challenges at the productions side. Lack of financial facilities to upgrade existing machine and problem of collateral to scale up the business were critical issues for processors to expand rice business venture.

The project attempted to address both issues mentioned above through assisting the establishment of Village Saving and Loan Association (VSLA) at producer's level. The VSLA are self-managed groups that provide people with a safe place to save their money, access small loan, obtain emergency insurance, and improve financial literacy. Each group is composed of 10-20 people who use the money saved within the group to provide loans to one another and take part in income generating

activities. The groups also develop a *social fund* in order to assist group members in periods of distress.

During the establishment of VSLA, client farmers of EDGET project have given priority to form the group. This improves the financial literacy of the group, increase cohesiveness of the extension group and also solve small financial problems to access seed and other inputs that boost the productivities of rice.

Saving mobilized from:	**Amount (Birr)**
Regular savings	125,487
Social fund contribution	17,632
Fines and Interest	9,939
Cumulative value of savings mobilized (1+2+3)	*153,058*
Cumulative value of loan disbursed	82,739

So far, 84 VSLA groups are established with total members of 510 (124 women) project client farmers that create access to finance based on their demands. The group has mobilized a total capital of 153,058 birr from regular savings, social funds, fines, and interests.

Because of those supports, VSLA groups were able to build financial literacy skills, provide access to credit when needed, address farmer's mistrust of formal MFIs and RUSSACCOs while providing a place to save/borrow money. The VSLA serve as a platform to discuss other social issues (HIV, gender issues), being accessible to the illiterate, and poor. The social fund is used to mitigate risks and motivate to engage with other income generating activities. So far, 8 VSLA have linked with local MFI/ACSI for sustainability and better access to credit, enhance market group activity, improve market knowledge, product distribution in local markets, strengthening bargaining power, and thereby reducing e transport costs. Furthermore, P**artial Credit Risk Guarantee Facility (PCRGF)** has been signed with Buna International bank to finance small and medium enterprise (SMEs) in the rice sector. Until this time, six rice miller/processors have accessed working capital loan amounting 1,780,000birr. This inspired them to invest more in the rice sector and worked carefully on the quality of the sector. Assistance provided for SME on basic bookkeeping and follow-up on repayment of their credits increases their confidence on the business profitability.

Project management, coordination, and networking

To improve the project performance different tools have been proposed to ensure utmost coordination, management and networking among the chain actors

- Project steering committee (PSC) with members comprising of donors, project signatory office heads, and project managers is the upper decision maker. The PSC conducts its annual meeting every year; it reviews previous year performance and plans for the upcoming fiscal year;
- Multi-Stakeholder platforms (MSP) - The forum serves to bring all actors together at regional level to create common understanding/vision, address sector development issues, create business-to-business relationships, disseminate sector information, best experiences, and influence policies. At the forum all actors come together to make a dialogue that ensures trust and confidence between actors through win-win relationship. It is held twice in a year at the regional level. Participants are pulled from the private sector including input suppliers, producers, processors/collectors, cooperatives, business service providers, super markets, wholesalers; public sector including representatives from regional, zonal and woreda service delivery agencies, research, universities; and others NGO's. It has normally between 55 and 60 participants;
- Project Technical Advisory Committee (PTAC) pulled from various sector offices and representatives of private sector meets every quarter to review the implementation process of the project from the technical sides of the project. It is led by a chairperson selected from the representatives and the project staff serves as secretary. Their number is not more than 15 unless special speakers are invited for peculiar reason.
- Quarter performance review and planning forum – a meeting conducted at the local level (*woreda* level). The meeting is amid to review pervious quarter performance and agree with next quarter plan. This forum stimulates all actors to expedite actions taken on their part. Representatives from producers, processors, collectors, and relevant service delivery agency at District public office and representative form zonal office attend the meeting. Attendants took responsibilities to execute until the next meeting. 35-40 forum attendants expected to participant;
- Monitoring and Evaluation - the project has an internal M and E systems that focuses to measure the immediate and intermediary outcomes of the project. The project has conducted baseline survey before the commencement of project intervention. Every year, annual household survey is conducted to see changes against the baseline data or information. Besides, recording success stories, assessing the impact of a given training are most important tools used to supplement the annual survey result;

- Cross cutting issues - efforts have been made to increase the participation of women at different level of the interventions including parboiled technology supply, support to attend all pre and post-harvest capacity building training, special discount for technology adoptions, preparing illustrative materials for training sessions. Regarding environmental safe guards measures, training has been mainstreamed in all pre and post agronomic training for producers. Besides, machine operators have received training that focused on proper disposal and management of husk and bran, energy consumption and saving, as well as health and safety measures to avoid environmental pollutions.

Lessons and conclusion

From the practical interventions, the project has documented so many lessons. Among them, the following can be shared

- Not only the type of machine that greatly affect the breakage of the rice but the management of pre and post-harvest handling matters more than the quality of the machine to process the rice. Hence, due attention must be given to pre and post harvest management of the rice to improve the quality of whole grains;
- Introduction of new technology requires full knowledge of all parts. So it is always good to have all the details, know-how to manage the new ways of doing things and preparation of all the packages for a given technology for its effective adoption;
- Out-growers lead seed multiplications initiatives shall be supported and coordinated with national/regional seed enterprises and cooperatives to solve seed problems;
- Producers and processors are suspicious of new ways of doing business. Most of them developed 'let us wait until someone succeed attitude'. This requires understanding of all dimensions of their experience and work out against their bad experience that built up trust and confidence on their fragile business relationships;
- Actors involved in the rice sector should collaborate and synergize efforts and experience to make a difference. They shall focus on building the private sector that can create sustainable provisions of new services and provide inherent incentives to self-regulate and adhere to quality standards. Such focuses will bring lasting increase of profitability and re-investment to improve the competitiveness of the sector; and
- A coordinating effort should be exerted by all chain supporters to stimulate private enterprises to demonstrate new technologies and scale up successful ones.

Promoting Rice Post-harvest Handling and Processing Technologies in Ethiopia

L. Halos-Kim

Sasakawa Africa Association

Introduction

Rice in Ethiopia has big potential to contribute to food security and even to generate foreign currency from its export. It has been formally promoted through introduction of different improved varieties since 2002 by the Ministry of Agriculture (MoA), the Ethiopian Institute of Agricultural Research (EIAR), the Japan International Cooperation Agency (JICA) and Sasakawa Africa Association (SAA)/Sasakawa Global 2000 (SG2000).

The introduction and release of high yielding upland rice varieties such as NERICA 1, 2, 3, 4 and Suparica-1 from Africa Rice Centre in 2007 have spurred growth of rice production in Ethiopia (SAA, 2012). The area planted with rice and production were only 6,000 ha and 15,460 tons in 2005, which has increased to 221,892 ha and 887,402 tons in 2010, respectively. The number of farmers planting rice had also increased from 18,000 to 565,442 in the same period (SG2000, 2010). As a new crop in the country, there were many constraints to expand rice production. Access and use of the associated post-harvest technology packages for efficient handling of the crop have been among the key constraints observed.

Rice post-harvest handling and processing services are still underdeveloped in Ethiopia, although SAA/SG 2000 has been introducing a number of post-harvest handling technologies right from the beginning of the rice promotion in the country. The rice post-harvest handling and processing in most of the rice production areas, except Fogera and a few other areas are still carried out using traditional methods that have resulted in poor quality and high losses.

The Post-harvest and Agro-processing Team of SAA/SG2000 has been promoting a range improved rice post-harvest and processing technologies in order to contribute to the reduction of the observed huge post-harvest losses within the rice value chain, which can provide additional incomes for farmers and processors. SAA/SG2000 has demonstrated and trained users on the use and operation of rice harvesters, threshers, cleaners, and mills since 2010.

This paper presents experiences of SAA/SG2000 rice post-harvest and processing technology promotion program, its accomplishments and challenges that still hinder the full adoption of the technologies in Ethiopia.

Handling, Processing, Storing and Utilizing Rice

According to Halos Kim (2007), the farmers' practice on rice harvest, post-harvest handling, and storage in Ethiopia is mostly traditional methods, which are of poor performance and cumbersome (Figure 1). Improved rice post-harvest technologies are unknown by many farmers and extension officers, except in Fogera and Gurafarda, where some commercial rice mills are in use.

The current post-harvest system presents problems of high losses, poor product quality, and limited utilization of the crop. This is associated with the serious availability and lack of access to appropriate tools and equipment along with lack of market information about the tools.

Harvesting and threshing

Harvesting is commonly practiced using scythes/sickles, which takes on average 40 person-days per hectare and another 16 person-days for collection and piling. Threshing is accomplished by trampling a number of oxen or donkeys, treading around on a pile of the materials, or beating the panicles on the ground covered with mat or canvass. It requires four to six oxen working for three to four days to thresh crop harvested from a hectare. Extended period of exposure of paddy in the field results in quality deterioration and higher loss due to microbial effects, physical losses from repeated handling, insect infestation, and direct consumption by cows, goats, chicken, etc. These are some of the bottlenecks during the harvesting season as human and animal labors are not easily available. Improved harvesting and threshing techniques are required to minimize the loss.

Winnowing, cleaning, de-stoning

Farmers clean threshed paddy by tossing into the air blowing off most of the light chaffs and other impurities. This method could not separate the stones, soil and weed seeds mixed with paddy, making it inferior in quality. Cleaning is a necessary process as clean paddy stores better and further processing, such as milling, is more efficient.

Drying

The high air humidity during harvesting, notably in southern part of the country, necessitates some degree of drying before the paddy is stored. Sun drying by spreading the paddy thinly on mats or canvass in farmers' yards or fields is a common practice. This practice could take three to five days depending on the weather condition. The delay in drying entails labour costs to farmers and can result in physical losses due to repeated handling and qualitative losses due to deterioration. This system is still manageable at the current production level. Development of on-farm dryers will be a priority in wet areas as the high humidity can contribute to grain deterioration and substantial losses.

Milling

In Oromia and Afar Regions, milling is still done by pounding small quantities of paddy using mortar and pestle at the time it is needed and according to the amount to be consumed. The resulting de-hulled rice (brown rice) is further processed in a maize mill to grind into flour if the rice is to be used in the preparation of enjera. In SNNPR, paddy is milled in commercial mills operated by enterprising traders/businessmen providing services to the farmers. The rice mills, mainly the Engleberg type, are powered by diesel engines. The operators noted the constraints as unpredictable supply of diesel because of its distance from the town and cities. Some villages have electricity, which can be tapped to drive the motors for the mills. Availability of spare parts is also another constraint mentioned by operators. There are currently more than twenty units of at least three types of mill, operating in the Fogera area in Amhara Region: the Engleberg type, the most

popular; the Rubber Roll Mill (SB-10 model from China) and one or two locally manufactured mills, an under-runner disc mill. Despite this, there is still a big gap between the milling capacity and the volume of grain production. This gap will be significant with the introduction and increasing adoption of new high yielding varieties, like Nericas, which is currently promoted nationally. In 2008, the rubber roll mills were introduced by SAA/SG2000 in Oromia and Tigray Regions, where rice cultivation was fast emerging. High amount of broken grains is observed and reported by the farmers. As there are many factors contributing to broken grains during milling, this has to be determined so that remedial measures can be developed to improve the milling recovery. Farmers and millers should likewise be informed, as they are key players in improving the post-harvest system.

Storage

Most people store paddy for household consumption in local stores called *gotera*, a local storage hut with a thatched roof and insulated with mud found in most farmstead. Storage could be up to three months. Paddy is drawn out of the store in small quantities as needed. Some farmers store paddy to use as seed for the next season. Gotera needs to be improved to protect stored grain from rat, insect infestation, and re-wetting of grain, which could result in deterioration. Indoor storage is still manageable at the current level of production. The volume of production should be taken into consideration to develop more appropriate storage facilities to avoid losses and maintain the quality of paddy in storage. For convenience, paddy and milled rice are stored mostly in bags by the traders and millers. The bags are stacked in several layers on top of a wooden palette or logs. This practice facilitates management and aeration of the stored batch. Care must be

taken to keep the bags tightly closed to avoid physical loss due to spillage.

Utilization

Rice is a new crop in Ethiopia that is becoming a staple food in some regions especially where tef is not grown in large scale, and where imported rice is available. It is consumed as plain or parboiled rice; ground to flour and used in the preparation of *enjera*. With the development of rice products by the SAA/SG2000 Agro-processing Program, other types of rice recipes are being introduced. Though rice farming is not yet adopted widely in Afar region, people have consumed rice long before, as it is their staple food. Imported rice is supplied from the neighboring countries, Djibouti and Somalia. Parboiled rice (Basmati) from Pakistan, India, and Thailand is more popular among the population. The much of the local rice is from Fogera area in Amhara Region. The increasing price of rice over the last three years prohibits the people from increasing their consumption. The increase in price is due to scarcity of supply. The local traders could not afford the high cost imposed by the wholesalers and importers. Growing the crop locally could solve the problem.

Promoting Post-harvest and Processing Technologies

With the introduction of new rice varieties in Ethiopia in 2002, SAA/SG2000 Agro- processing Program introduced the multi-crop thresher and rice mill to some farmers. The program also developed rice

food recipes adapted from the Ethiopian food system in collaboration with the MoA and the Ethiopian Health and Nutrition Research Institute (EHNRI). It also trained housewives on rice food preparation and explained the benefits derived from rice. To date, SAA/SG2000 continues to disseminate relevant post-harvest and processing technologies in conjunction with the promotion of production-enhancing technologies, adopting a value chain approach. The technologies introduced by SAA/SG2000 include mechanical reaper/harvester, thresher, cleaner, improved sun and mechanical dryers, rice mills, on-farm storage and their associated management (Figure 2). This is done through demonstrations, field days, and trainings. The farmers were also linked to markets.

The introduction of post-harvest technologies has encouraged more farmers to grow rice, as they are able to process the crop quickly and maintain the quality. Improving the production system can increase production by two to three folds, while post-harvest and processing technologies increase quality, which can bring about increased income to the farmers and processors.

There had been notable regional initiatives to introduce improved post-harvest handling and processing of the ever-increasing production of rice. The main interventions are

- Between 2005 and 2007, with funds secured from the Somali Regional Food Security Bureau, 6 rice mills and 12 multi-crop threshers were purchased for the Farmers Research Groups (FRGs) in Gode, Addadle, and Kelafo areas. In anticipation of the increased demand for these machines, introduction of, and training on thresher and rice mill operations were conducted;
- Motivated by market demand, the processing of parboiled rice had

been adopted in the Fogera area where rice is consumed as white rice; women groups were trained on processing and were also linked to markets;

- Experience sharing visits from main rice producing areas had a chance to visit Fogera area to observe and exchange information and experiences on rice post-harvest handling and utilization. Similarly, these farmers also visited Selam Vocational and Technical College (SVTC) in Addis Ababa to learn the principles of operation of the rubber roll rice mill;
- Development of rice recipes that fits the local circumstances is underway mainly in the major producing areas like in Amhara region (Alemayehu, 2007); and
- In Tigray Region, rice mills are introduced in 2011-2013 and are now being adopted. Millers provide services to farmers in the villages and earn income from the operation and farmers get access to better markets due to improved quality of their products.

Addressing Challenges in Promoting Post-harvest and Processing Technologies

SAA/SG2000 still faces many challenges to sustain the interest and adoption of improved rice post-harvest technologies in Ethiopia. Technologies proven to work in other developing countries are not easily available in the country. They are still unknown by many farmers and processors. SAA/SG2000 works with public and private development institutions and suppliers to improve the supply of technologies in the country. It has trained local manufacturing enterprises how to fabricate machine parts and undertake needed repair and maintenance works.

The cost of the technologies and their importation hinders development

institutions to demonstrate and adapt the technologies to local environment. Unlike the successful adoption of tef threshing service providers in SNNPR, adaptation of threshers in rice production is yet to come.

Rubber rollers and belts of rice milling machines wear off fast because of extensive use, but spare parts are not available in the country. Since there are only few units of the machine, the demand for a constant supply of parts is still not recognized as a good investment by importers.

SAA/SG2000 provides technical and practical training to extension and development agents none of whom have training on basic post-harvest system but are responsible in demonstrating post-harvest technologies and in training farmers and processors on their use and management.

There are insufficient research facilities and instrumentations to better analyze and understand the science of post-harvest and processing operations in order to deliver better options to improve the post-harvest system.

The cumulative effects of the stated challenges then are the supply of poor quality rice from domestic production. Poor paddy and milled rice are sold in the markets side by side with imported rice. There is no regulatory body to check and control the quality of rice brought to the market. The market is controlled by private traders, who buy rice without consideration of the quality. There is no price incentive for good quality rice.

Conclusion and Recommendations

SAA/SG2000 has put a substantial effort in promoting improved rice post-harvest and processing technologies in Ethiopia, which encouraged many farmers to adopt rice in their farming options. The strategy to address the rice value chain had proven to be effective in demonstrating the importance of the crop in providing food and income security for farmers and processors. Initial adoption of the technologies sparked the interest of farmers to adopt the technologies.

The successful implementation of post-harvest technology introduction in Ethiopia will depend on the type of technologies, its accessibility to farmers and the commitment of the government and partner agencies to support the rice promotion in the country. The following actions are recommended to facilitate the adoption of improved post-harvest and processing, as well as other agricultural technologies.

- Increase investment in post-harvest development, including training of post-harvest professionals, by government and other rural development institutions;
- Public policies and services need to provide due attention to the following key issues
  - putting agro-processing into focus in the agricultural development agenda;
  - institutionalize agricultural mechanization in public service provision;
  - exploring the establishment of efficient supply system for fabrication materials and spare parts for agricultural machines;
  - promoting introduction and continuous supply sources of wide range of rice post-harvest technologies to ensure their availability in the country;
  - supporting local rice related product and technology development;
  - facilitating improved value addition through efficient quality control systems and adequate supply of associated inputs like packaging materials; and
  - facilitating the development of local market and linkages of the different actors.

- Promote coordination of efforts and resources of relevant development partners in rice sector development; and
- Encourage participation of more private entrepreneurs in the rice industry

The availability of improved post-harvest and processing facilities will push the adoption of rice in Ethiopia sooner than expected. This introduction will require many investments on training human resource to spearhead the development and popularization of technologies appropriate to the environment. A multi-disciplinary team needs to be constituted for the full implementation of rice post-harvest program in Ethiopia.

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Japan's Experience in Rice Mechanization and Development Initiative in Africa

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Introduction

Rice mechanization was achieved in Japan by early 1980s from seedling preparation to harvest operation by remarkably reducing time requirement. FAO (2008) illustrates the poor state of sub-Saharan Africa (SSA) by the extremely low number of tractors. There were 2 tractors per 1,000 ha of farmland in 1980 in SSA but this had sunk to 1.3 in 2003. In Asia, tractor use over the same period increased tenfold. Is there any chance for SSA countries to mechanize farm operations of small-scale farmers? Many countries in SSA have come up with agricultural mechanization policies, and strategies, but few countries successfully promoted tractors and animal draught power.

This paper discusses Japan's experience in terms of administrative actions taken by the government after World War II (WWII) and other supporting actions that followed the systematic rice mechanization. In comparison, the situation of agricultural mechanization in SSA is described and a recent change of the economic environment in SSA is stated. Coalition of African Rice Development (CARD) has been tackling rice mechanization in some pilot countries. The progress of their activities is briefly described and its implications for rice mechanization in Ethiopia are discussed.

Agricultural Mechanization Policy

The Agriculture Foundation Law implemented in 1961 directed the Japanese government in promoting agricultural production, price and market control, agricultural structural adjustment, and agricultural

administration. The law was thoroughly revised in 1999 into the Foundation Law on Food, Agriculture, and Rural District including food security from the aspect of the consumers.

The Agricultural Mechanization Promotion Act has been instrumental in increasing the use of high performance agricultural machineries in farm operations. It consists of research and development, finance, type certification, instruction to local government, and penalties against violations. This act describes the roles of the Institute of Agricultural Machinery (IAM) that is the key organization to lead the agricultural mechanization process in Japan.

The Agricultural Modernization Fund Act came into effect in 1961. It has facilitated farmers' access to modern inputs and machineries. It includes low interest rate and long-term loans through agricultural cooperatives, and subsidized interests by central and local governments.

In addition, the Land Improvement Act became operational in 1949. The act promotes water user associations in land improvement districts with subsidies to improve, develop, conserve, and consolidate agricultural land. The land consolidation has improved agricultural machinery use efficiency and reduced cost.

Promoting Agricultural Mechanization

IAM was established in 1962 by the Agricultural Mechanization Promotion Act as a specialized institute for research, development as well as testing and evaluation of agricultural machineries. It is in charge e of the National, OECD, and IAM Tests. For example, head feeding type combine harvesters and rice transplanters (rotary transplanting mechanism) were developed by IAM. When the Regional Network for Agricultural Machinery (RNAM) was established under United Nations Economic and Social Commission for Asia and Pacific (ESCAP) in 1977, Japan participated as a supporting country and IAM took an important role in technical back stopping of the network.

The Japan Agricultural Mechanization Association was established in 1957 to contribute to agricultural development through improving farm management and agricultural mechanization practices. The members are

the National Federation of Agricultural Cooperative Associations and agricultural machinery manufacturers. Their main activities are to introduce and disseminate superior agricultural equipment, promote safety measures, provide database of new machinery and price information of second hand equipment, promote machinery rental services and participate in the international technical cooperation.

The Japan Farm Machinery Manufacturers' Association, founded in 1939, contributes to the development of agriculture, through promotion of farm machinery by streamlining the agricultural machinery industry. Its activities include lobbying for promotion of agricultural mechanization, supporting machinery development, standardization, promoting model inspection, safety appraisal, improving maintenance services, promoting external trade, and study on safety and environmental issues.

An Agricultural Machinery Bank System was introduced in 1972 to improve machine utilization rate by matching service providers of farm operation with high performance machinery and farmers. The major service providers are agricultural cooperatives targeting their members. It was started with eight banks and it reached to over 700 in 1988 with more than 400 service providers covering an average service area of 500 ha.

Licenses with grades of I and II categories are issued to technicians. The licenses are issued by the Vocational Capacity Development Association of each local government. The number of certified technicians is over 55000 at present. Each local government also issues certificate agricultural machinery operators, instructors, and maintenance workshops in small, medium, and large categories.

Trend of Agricultural Mechanization

Japan's agricultural mechanization started as early as 1930s as shown in Figure 1 (JFMMA, 2013). In the early stage of mechanization, postharvest machines such as power threshers and rice hullers were introduced. It was closely related to the Japanese government's control of rice prices. The government also purchased rice from farmers in a form of brown rice and the price was determined according to the quality of rice. To meet the requirements, farmers used threshers for timely

operation and rice hullers for better quality rice. Accordingly, field operations such as tillage were mechanized. The number of power tillers exceeded three million units in the 1970s then they were replaced by 4-wheel tractors. Transplanters and combine harvesters were introduced in the 1970s, where one could say rice production system was fully mechanized.

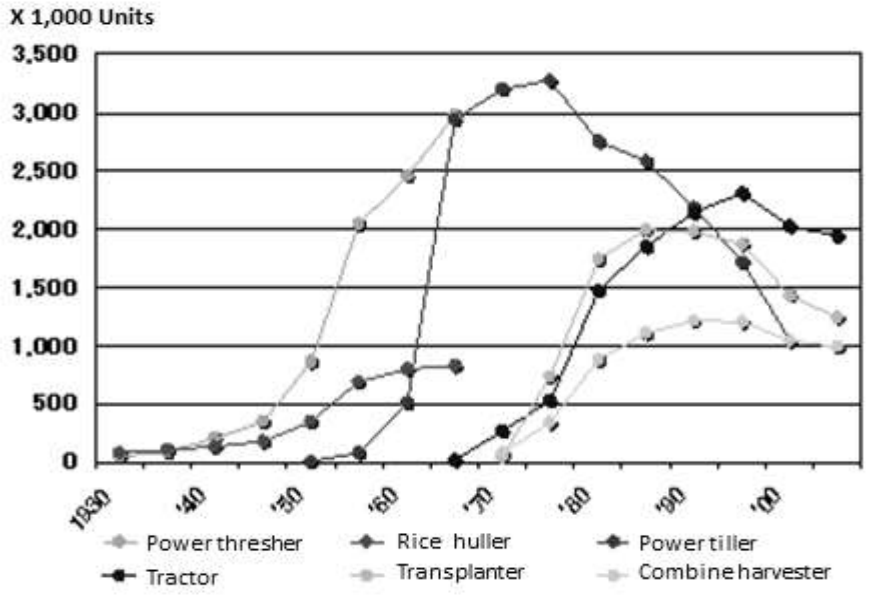


Figure 1. Number of major agricultural machinery on farm in Japan (1930-2010)
Source: http://www.jfmma.or.jp/CCP050017.html

As shown in Figure 2 (JFMMA, 2013), rice yield reached over 5 tons/ha (this can be computed to be 6.25 t/ha in the rough rice base if husks weigh 20% of rough rice) in 1995. In addition, annual working hours to produce rice in 0.1 hectares was less than 50 hours in 1990s. This significant reduction of working hours was brought by mechanizing transplanting operations. In addition, use of large size tractors as well as combine harvesters contributed to reduce the required time of operations.

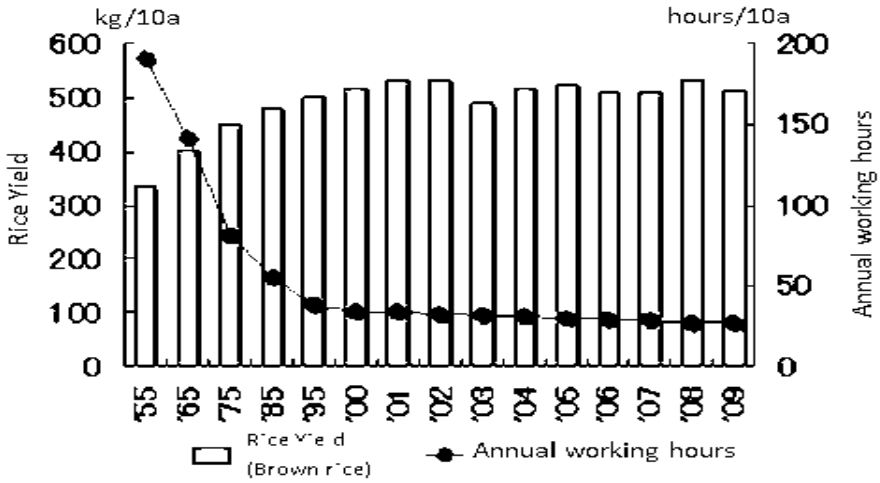


Figure 2. Rice Yield and Annual Working Hours on Farm in Japan, 1955-2009.
Source: http://www.jfmma.or.jp/CCP050017.html

Agricultural Mechanization in sub-Saharan Africa

Tractor mechanization was intensively promoted as a part of large-scale agricultural schemes in the 1960s in SSA. On the other hand, farms were distributed to individual farmers after independence. To meet the new demand by small-scale farmers, animal draft power was spread as an intermediate technology for SSA. However, it was practiced well before the 20th century and sustained in a few countries such as Ethiopia animal draft power remained in limited use in most part of SSA. The unpredictable droughts and the epidemics of animal diseases hit many parts of Africa and they prevented farmers from using animal power. The intermediate technology was not able to meet the demand of the majority of small-scale farmers. Bishop Sambrook estimated areas cultivated by different power sources, and reported that 50% use work force, 32% use animal draught power and 17% use mechanical power (IFPRI, 2010).

The number of tractors in use in selected African countries is given in Figure 3. Tractor use has been gradually increasing, but less than 30,000 units were reported in many countries.

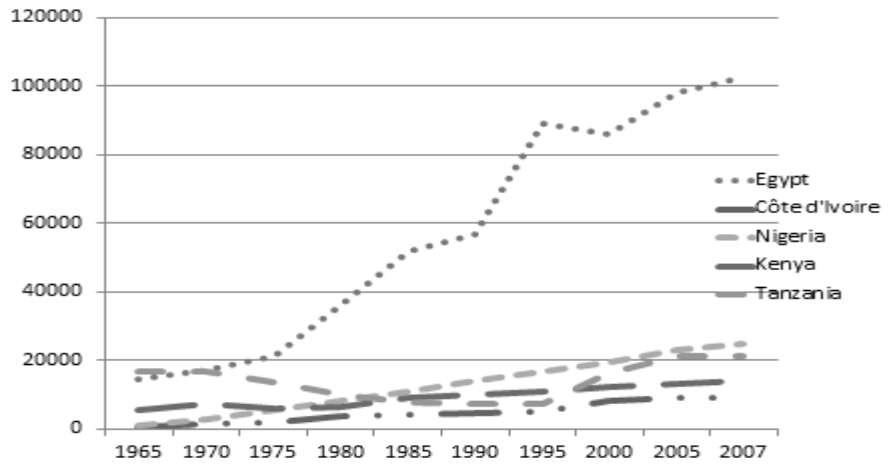


Figure 3. Tractors in Use in Selected African Countries (Units), 1965-2007
Source: FAOSTAT website, 2010

To promote tractor use among relatively small scale farmers, tractor-hiring schemes were operated as a government service, however, many of those failed to operate. Identified causes include technical problems of imported machines, management failures under bureaucracy, shortage of public financial support, low incentives for operators under public service, and low machinery productivity. Kaul (1991) pointed out that their beneficial effects can be offset because of distorted mechanization policies, which usually benefit the capital-intensive large-scale farmers. Tractor hiring schemes were privatized in several countries in the 1980s and 1990s as a part of structural adjustment programs.

Experiences of Governments and Donors

Beside many private sector initiatives, there have been several government interventions and donor supported projects implemented to mobilize agricultural mechanization in SSA. These actions and experiences include:

- Subsidize delivery of machinery and equipment to farmers;
- Import agricultural tools, implements and powered machines with tax exemptions;
- Promote tractor hiring services;
- Repair maintenance by machinery dealers and entrepreneurs;

- Research and development of machines with locally available materials;
- Develop and produce simple tools and machines;
- Educate and train engineers, technicians, extension workers, operators and farmers;
- Provide commercial financing and soft loans; and
- Regulate work and standardization

Some of the above worked well in a specific place and time, but did not achieve the expected goal. Many factors complexly related to one another and any single action was not able to attain a sound agricultural mechanization scheme. For example, there was a negative impact of machinery subsidies on the promotion of the private sector. Many donors and political leaders directly delivered agricultural machines to farmers with no payment. This action distorts the market, and private sector receives shrunk market with unfair competition. This also gives negative influence on machine ownership of the farmers.

Constraints

Africa Rice Centre (AfricaRice) invited representatives of rice stakeholders to a workshop on "Boosting Agricultural Mechanization in Rice-based System" in St. Louis, Senegal in June 2011 to develop a roadmap for boosting agricultural mechanization in the SSA. Based on the constraints faced by key stakeholders in mechanization, factors to promote agricultural mechanization were discussed. Some of the constraints identified in the workshop are listed below.

- Low purchasing power of farmers and less availability of low cost agricultural machinery;
- Limited access to agricultural credit for farmers and local fabricators;
- Low utilization of machinery and low volume of business resulting to poor cash flow;
- Lack of suitable machinery packages for main agricultural operations;
- Poor quality tools, equipment and machinery;
- High local production cost due to imported materials;
- Unstable spare parts supply and post sales service;
- Limited human resources such as trained operators and mechanics for farm machinery;
- Inadequate business knowledge and poor technical knowledge in agricultural machinery; and

- Few private sector led programs based on clear mechanization policy and strategy

Farmers in SSA may face these constraints simultaneously and struggle to get and operate machinery in their farms in most cases. These constraints may not be easily removed unless agricultural machinery stakeholders find a new approach and a framework suitable for contemporary SSA. It should be led by the public sector, because it may not be possible for private sector to invest in all aspect of mechanization requirement.

Agricultural machinery in SSA work in difficult conditions such as irregular shape fields, hard soil and other tough conditions such as high temperature and dust. It is necessary to overcome technical difficulties such as the durability requirement when agricultural mechanization is considered. The most important aspect is farm management when agricultural mechanization is planned for individual farmers. Diverse people create diverse types and models of farm tools and machines to meet their own need. Standardization may not be always necessary for end users if off standard hoes are regulated and demolished from the market. In the market economy, de facto standard should be employed to reflect actual users' need for sound mechanization. To improve compatibility of farm machinery, it is necessary for the government to apply regulatory actions to standardize the design of machine elements especially for safe use of agricultural machinery. It is the manufacturers' responsibility to reflect the farmers' needs including after sales services.

There are research and development institutes for agricultural mechanization in most SSA countries to respond to the demand of local farmers.. These institutions try to come up with an original design suited for their recipient farmers. However, it is more efficient to modify designs developed by international organizations such as the International Rice Research Institute (IRRI) and AfricaRice. They develop relatively simple machines designed for smallholder farmers, but these developed machines are not always appropriate for all farmers in SSA, because conditions of machine use are quite different and the after sales support services are weak in some SAA countries. It is necessary to have a more efficient framework under international organizations to develop machines because qualified agricultural engineers in developing countries are one of the hardly available resources.

It is critical to have enough number of skilled and qualified personnel in the agricultural machinery supply chain to promote appropriate agricultural mechanization. Higher education receives higher priority in the agricultural engineering sector, but a number of people are required at technician level to mobilize the functions of the sector. University education is paying too much emphasis on theoretical aspects in some SSA countries. It may be required to obtain a degree, but a paper cannot solve the problems that farmers face, unless it is implemented as a development program or project.

Lessons Learned

The stagnation of mechanization has been experienced in many SSA countries. The causes may differ from place to place and from time to time. There is no single model of mechanization that can be applied to all SSA countries. The conditions for mechanization are not the same and may not be favorable in specific places. However, there are several empirically known pre-conditions to start agricultural mechanization.

First, one is profitability. By mechanizing the farm operations, farmers should have more profit than before. Mechanization is costly especially fixed cost is too much to recover for many cases. This may not be applied only to farm operations, but also for non-agricultural activities. When machines are introduced, farmers expect to spend less time on the farm. It is, however, not easy to transfer the availed time by mechanization from farm work to other value added activities or moneymaking work.

Secondly, technical feasibility is assured. All countries try to stimulate the use of agricultural mechanization technologies, but selection of machinery is sometimes not adequate. One of the examples is rubber wheeled tractors used in swampy conditions. It cannot perform to its maximum capacity under inappropriate conditions.

Thirdly, the machinery supply chain is functional. All the stakeholders in the machinery supply chain should get enough margins to sustain their business activities. If a link of the supply chain is broken, the business model is no longer functional. The cost should be recovered within the supply chain and all stakeholders should make some margin from

mechanization to sustain their business. Therefore, the total volume of the potential market and business is critical to determine their profitability.

Fourthly, business risk is minimal to promote foreign investment. It is important to have a concrete policy to promote agricultural mechanization because it requires a long-term perspective and continued commitment from the government. Political and social stability is one of the indicators of country risk, and SSA countries are required to show stability in terms of sustainable economic performance. Economic change is always a risk for investors, but the political and social risk should be avoided by maintaining peace and order.

Favorable Changes in African Economy

The economy in Africa has been steadily growing except for some socially unstable countries since the beginning of the 21st century (Tokida, 2013). Figure 4 shows that direct investment inward flow to Africa is rapidly growing except in Northern Africa where it experienced disturbance by Arab Spring. Western and Eastern Africa showed about 5 times increase in the volume of inward direct investment without major fluctuation since 2000. This is a clear indication of the steady growth of African economies.

The world trends in agricultural mechanization show that economic growth and mechanization have strong correlations. The countries with steady economic growth in Asia have achieved agricultural mechanization, although their mechanization level was not so different from SSA situation when they started mechanization several decades ago. It is time to shift from subsistence agriculture to commercial agriculture and from hand tools to agricultural machinery.

Figure 5. Real GDP Growth Rate (%), 2003-2013.
Note: Fiscal year July (n-1) /June (n), Fiscal year (e) is an estimation and Fiscal Year (p) is a prediction

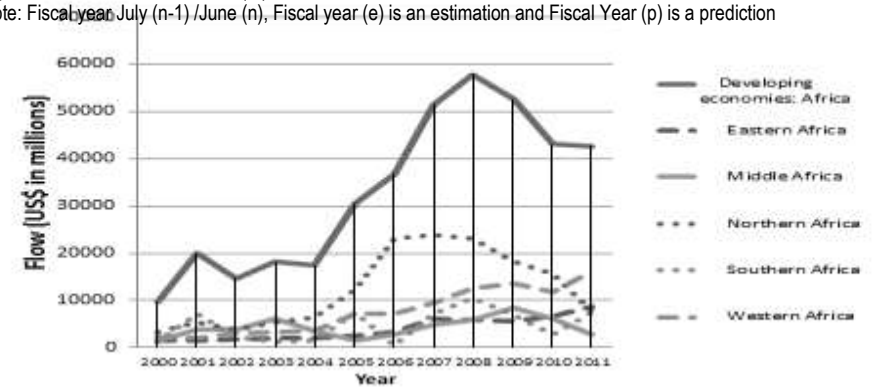
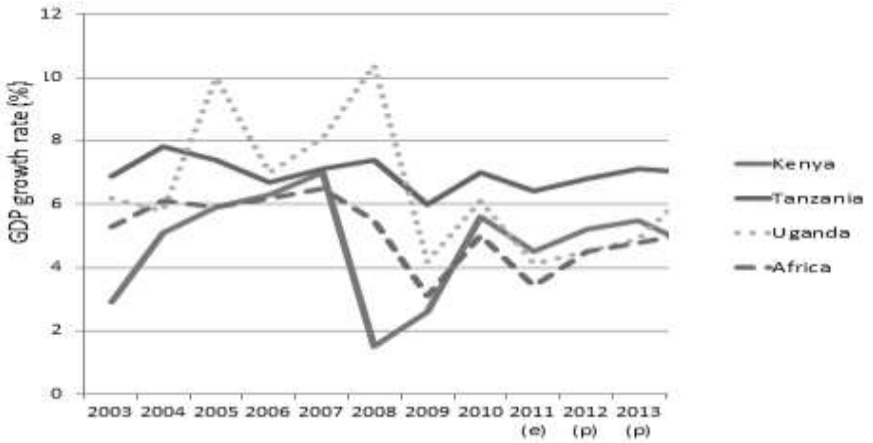


Figure 4. Inward foreign direct investment flows annual, 2000-2011.
Source: UNCTAD-STAT, Inward and outward foreign direct investment flows, annual, 1970-2011



Sources: African Economic Outlook (African Development Bank Statistics Department, Various domestic authorities and AfDB estimates)

Figure 5 shows the real Gross Domestic Products (GDP) growth rate of Africa and some selected countries in East Africa (African Economic Outlook, 2012). Over the period from 2003 to 2013, the average GDP growth rate was 5.1% in Africa. Tanzania reaches its average growth rate of 7.0% without dropping below 6.0%. The stable and consistent GDP is one of the major reasons of steady inward flow of foreign direct

investment. It is considered that the business environment in Africa has been changed by globalization of the economy, and Africa is now providing firm business opportunities.

In the first decade of the twenty first century, there was a food price hike due to world food crisis. It provided more incentives to African farmers to produce more crops, because it has more returns if they open new land to increase the use of fertilizer. Figure 6 shows the outlook for prices of three agricultural commodities, namely maize, rice, and wheat in Kenya. After the food crisis in 2007 and 2008, the price of some crops declined. However, it is believed that the price of rice and other grains in the international markets will stay at high levels in the near future through a combination of factors such as increased demands and changing consumption patterns in countries with growing economies, competition from production of bio-fuels from grains, and possible effects of climate change.

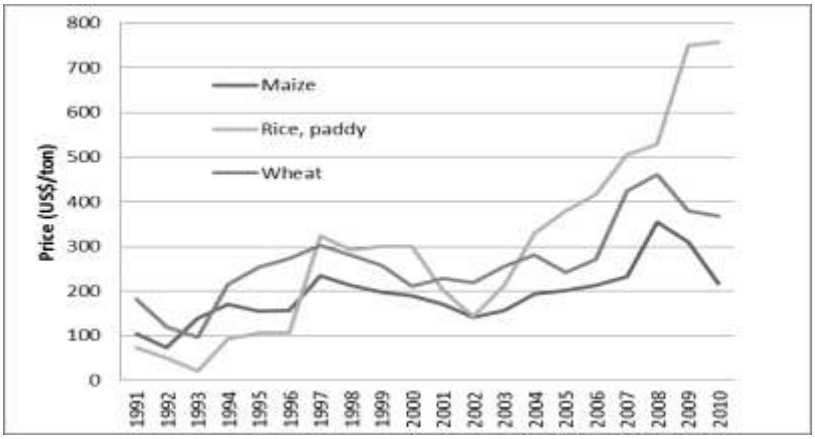


Figure 6. Producer price for major cereal crops in Kenya, 1991-2010.
Source: FAO STAT 2012
http://faostat.fao.org/site/703/DesktopDefault.aspx?PageID=703#ancor

African farmers are more interested in cash income from farming rather than food production except for a few subsistence farmers. Most African countries import food because they cannot produce food to meet their domestic demand due to growing population and economy. On the other hand, the growing economies such as China and India are critically important in stabilizing the agricultural commodity price in the international market. The price will remain high for some years. This situation creates a crisis for food importing African countries to pay a lot

of foreign exchange to meet the domestic food demand. However, only Africa can save the increasing world population by providing food to the world. High food prices can be a driving force to have more food production and agricultural income. The high food price generated more agricultural income to farmers and producers, and it enhances more investments in agriculture especially in agricultural mechanization. The economic growth also increased labour costs and it lead to agricultural mechanization rapidly, although the increase in oil price accelerated cost of agricultural inputs and farming practices.

The major cereals traded in the world markets are wheat, corn, and rice. Wheat and corn are widely traded and their annual traded amounts are estimated 130 million tons and 90 million tons respectively, while rice is mainly produced and consumed in Asia with a thin market of 30 million tons per year. African countries are major importers of rice and the consumption and importation has reached the level of million tons and 6 million tons of milled rice respectively. The rice production in SSA is continually being increased while rice import maintains around 10 million tons of paddies as shown in Figure 7.

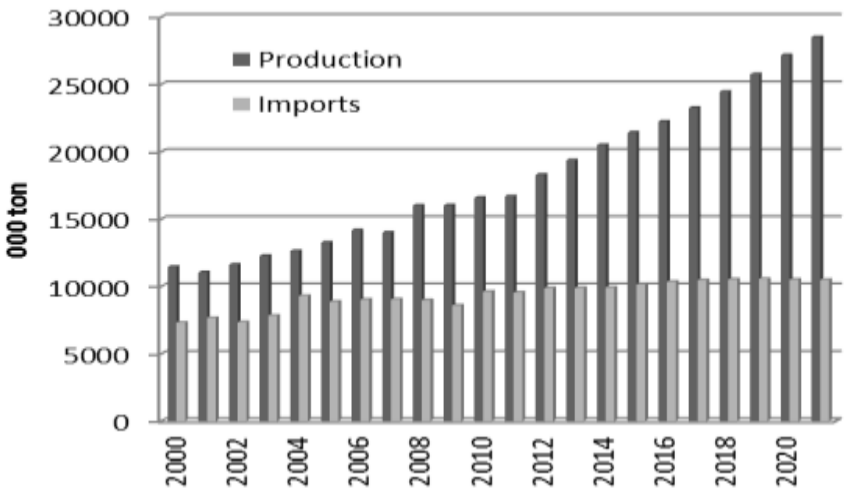


Figure 7. Rice production and imports in sub Saharan Africa
*The unit is kt (for Biofuels in millions of liters)
Source: OECD-FAO Agricultural Outlook 2012-2021
http://stats.oecd.org/viewhtml.aspx?QueryId=36357&vh=0000&vf=0&l&il=blank&lang=en

In Asia, increased rice production has been achieved through an increase in the yield per unit of land, whereas in Africa the expansion in cultivated land is the primary factor in the increase of total rice output. It can be said that among the staple food crops, rice represents Africa's best opportunity for reduction of imports. An increase in the yield will be required if there are constraints to shift the land use from traditional crops to rice. Any increases in local production will replace rice imports purchased with foreign exchange, and it will be reinvested in agriculture with reserved foreign exchange from importing rice.

Trends of Agricultural Machinery Industry

Globalization of economy significantly influenced the production of agricultural machinery including tractors. Tractor manufacturing companies in developed countries started to shift their manufacturing factories from their original countries to Eastern Europe or Latin America countries considering global markets. Japanese manufacturers started to produce tractors and other equipment in Asian countries. Growing economies such as China and India produce agricultural machinery for domestic use and for export. Since then, they have continued their efforts to produce domestically machinery by improving product quality to be competitive in the international market.

The agricultural machinery production was expanded to emerging countries in the last two decades. If these countries continue to supply less expensive machines to the world market, the availability of agricultural machinery will be expanded to other developing countries, which can be a driving force to promote mechanization in SSA countries. However, more import of machines from emerging countries may cause problem to SSA countries unless they build their own capability to manufacture agricultural machinery domestically with competitive prices.

CARD Initiative and Agricultural Mechanization

CARD was established in 2008 aiming the rice production in Africa be doubled from 14 million to 28 million tons by 2018. Agricultural mechanization is one of the most important agendas to achieve rice production increase twice as much by having timely operations, both in upland, lowland and irrigated land. CARD considers that not only rice

production, but also other crops, for on- and off-farm use should be mechanized to increase profitability by having high utilization of machinery.

Agricultural mechanization is listed as one of the components in the National Rice Development Strategy (NRDS) of CARD member countries, although, some countries do not have clear agricultural mechanization policy or strategy. After starting implementation of NRDS, many countries recognized the importance of agricultural mechanization to boost rice production. Tokida et.al (2012) reported that agricultural mechanization was brought as an important agenda in the CARD process as shown in Figure 8.

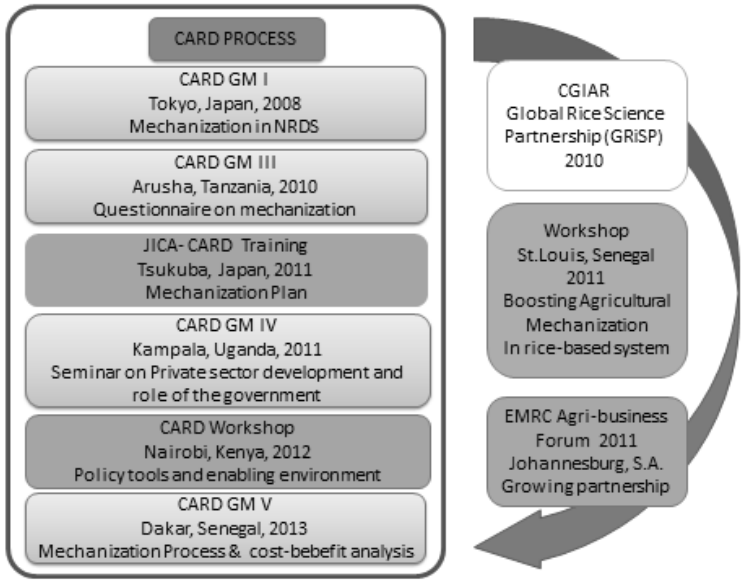


Figure 8. Agricultural Mechanization in CARD Process

Survey conducted during the CARD general meeting III

Some countries reported that mechanization strategy has not been implemented mostly due to lack of commitment by governments and the absence of detailed plans with funding to implement its strategy. Most countries shifted their tractor hiring services from the government sector to the private sector to improve efficiency and management quality except for some countries where very limited machines are owned by private companies or individuals. Most representatives from the participating countries reported d that the majority of rice mills are small

size privately owned and the quality of milled rice is poor. Thirteen respondents out of 16 were positive to avail small tractors to their farmers in one decade seeking Asian model agricultural mechanization. The three negative responses were that small machines are not suitable for huge land size of the country, initial investment in machines is too expensive for local farmers, and the land size too small to mechanize. Many respondents were also seeking agricultural machinery production including small tractors in their own countries in several decades. It clearly showed that planners in the government would promote privately led small mechanization in the end.

Promoting agricultural mechanization under CARD

Coalition of African Rice Development (CARD) is an initiative to double Africa's rice production to 28 million tons by 2018. In Asia, increased rice production has been achieved through an increase in the yield per unit of land, whereas in Africa the expansion of cultivated area is the primary factor for the increase in rice production. Agricultural mechanization is one of the most important agendas to achieve rice production increase twice as much by having timely operations, both in upland, lowland and irrigated land. CARD considers that mechanization should not only be reserved for rice, but machinery should be highly utilized with other crops, for on- and off-farm use. CARD selected seven pilot countries (Cameroon, Madagascar, Mali, Rwanda, Senegal, Tanzania, and Uganda) for agricultural mechanization and organized workshops two times in Nairobi in 2012 as a CARD process.

Almost all countries have agricultural mechanization policy or strategy in SSA. It is not always implemented very well. It is due to a weak commitment of the government in terms of limited budgetary allocation, limited human resources to implement the programs, poor monitoring system among others. The more critical constraint is difficulties of investment in agricultural mechanization caused by less profitability of farming in SSA. It is not easy to sell a small amount of cash crops in rural areas, and the price is dropped by having more supply of products in the market during the best harvesting season. In addition, the unstable rainfall pattern due to climate change creates more difficulties to farmers in stable production.

There was a myth that agricultural mechanization increased unemployment of farm workers who have no other sources of income in

rural areas. This prevented boosting of agricultural mechanization in developing countries. The argument was converged that mechanization provides more opportunities of employment in the value chain by having more quality products. However, it is not so easy to have high benefit in remote places from the market. The government has a challenge to reserve enough budgetary requirements for agricultural mechanization, because most policies and strategies, if not all, are formulated without the involvement of the ministry of agriculture and the ministry of finance in the development process.

Within the country, farming systems are diversified and the mechanization level is not uniform. Policy planners of each country are required to consider situations of smallholder farmers although large commercial farming is the main driving force for agricultural mechanization. This approach requires careful studies not only on farm machinery, but also on standardization of agricultural machinery for each country, provision of subsidies and tax exemptions; establishment of agricultural mechanization training centers for extension workers, technicians, and farmers. Based on the studies through dialogue among stakeholders, the natural and human resources and socio-economic situation should be well incorporated when the policy and strategy are formulated.

Enabling environment

Creating enabling environment for agricultural machinery supply chain is the most necessary action to promote sound and intensified mechanization in SSA. FAO 2008 stated minimum features of enabling environments and urged African governments to foster the development of mechanization with high priority actions such as improving rural infrastructure, strengthening agricultural support services, expanding the supply and effective demand. The enabling environments include providing direct support to companies involved in machinery supply and hiring services, reducing or absorbing transactions and information costs for mechanization services, promoting collaboration for provision of mechanization services, removing or reducing import and sales taxes on agricultural machinery and equipment, and making risk management tools such as insurance widely available.

It is important for farmers to recover investment in agriculture by securing output markets. Due to the lack of infrastructure such as roads

and bridges from farms to markets, it may prevent access to output markets as well as to agricultural inputs. Especially for land locked countries, the border is an obstacle to import materials and export agricultural products unless cross-border collaboration is available. Stable electricity supply is another important infrastructure for agro-processors to have uniform high quality products.

From the aspect of international manufacturers, it is critical to have a certain number of machines to produce or export to meet the demand. Suppliers are obliged to provide services such as repairs and supply of spare parts after sales. It is worth to export machines only to countries or regions with growing markets. Reduction of business risk is critical for foreign investors including agricultural machinery exporters. Transaction cost should be minimized. However, some countries require many days to issue a Letter of Credit and to clear customs when importing machinery. These costs are added to the sales price, and farmers are forced to buy expensive agricultural machinery. In addition, availability of crop and other insurances provides suppliers to secure margins if farmers could not get expected farm sales.

Provision of subsidies for agricultural machinery purchase could be a promoting factor to increase potential buyers. However, subsidy for vulnerable farmers is not always a right solution, because they have no access to credit. It is more important to improve access to machinery use for small farmers where the majority is African farmers. It is necessary to avail loans for beneficiary farmers with minimum collaterals.

These priority measures are considered to interact and some actions produce its effect when other interventions are available. It may have conflicts among measures if the target is not the same. Many countries have reduced import tariffs for agricultural machinery, but it is counterproductive for local manufacturers if they fabricate similar products for domestic use. Local manufacturers have to compete with tax exempted imported machinery, and they may need to use taxed imported low materials such as steel products and machine elements. If the government promotes domestic production of agricultural machinery, balanced measures are necessary for local manufacturers. Thus, enabling environment should be examined for its not only positive effects but also negative effects on other stakeholders. The CARD rice mechanization task force team in each pilot country worked on the list of stakeholders

and their requirements for thematic actions for mechanization with the necessary enabling environment and the role of government.

Private-Public Partnerships

As seen in many SSA countries, the use of tractors was enthusiastically spread through Tractor Hire Scheme by national programs in the 1960s and 1970s to expand food production and agricultural exports. The government-hiring scheme was not successful in many countries, because full support from the government did not provide fair competitiveness. Private sector development was considered the key to boost agricultural mechanization under structural adjustment. Following the structural adjustment introduced in developing countries, many countries terminated government-hiring services, and the private sector has taken up the initiative. It is, however, not easy to instantly shift its management from the government to private sector or farmers' group. In Uganda, sudden changes to private sector brought a negative impact as a significant drop of the number of tractors in use. The support from the government to ensure a smooth transition to the private sector is not adequately provided. Bishop (FAO 2005) argues that the absence of an enabling policy environment curtails initiatives by would-be adopters, particularly given the weak state of agricultural profitability. For example, tractor owners are extremely vulnerable to the withdrawal of government support.

There must be a clear policy on agricultural mechanization that promotes continuous private investment not only in agricultural machinery but also in agriculture as a sector. It includes legislative actions besides technical measures and economic interventions. It should eliminate unfavorable conditions as well as illegal actions that retard private investment in the sector. The policy should be based on long-term vision for agricultural development and the strategy should be reviewed periodically to reflect the socioeconomic situation to maintain sound competitiveness in the sector.

Human resource development is an important role of the government. A long-term perspective and intervention are needed to factionalize agricultural machinery supply chain to avail appropriate innovations to farmers. A technical issue is only a part of an entire system and socio-economic issues are very important and need to be considered accordingly. It is necessary to form a multi-disciplinary team with inter-disciplinary persons including the private sector in order to tackle highly complex problems in agricultural mechanization. It is an important government role to provide a more productive environment to create new ideas and diverse solutions considering dynamic changes in the future.

Availing only high quality machines in the market is critically important if end users have difficulties in their selection when purchasing machinery. Testing and evaluation of machinery and equipment are one of countermeasures to reduce or remove poor quality machinery from the market. However, it may not be justifiable for some countries to establish a machinery-testing center to evaluate and certify them without the appropriate number of qualified staff. Rather, it is recommended to establish an information sharing mechanism such as network for machinery certification. Information Communication Technology should be highly utilized for this purpose. Agricultural machinery database should be shared among organizations for machinery testing and evaluation at sub-regional or regional level. Usually national standards are regulated by an independent organization under the government, and it may not directly be linked to agriculture related ministries. It is important to have collaborative actions among ministries concerned on agricultural mechanization.

The private sectors should take action on producing quality machinery that is demanded by end users. There must be internal control measures among manufacturers and dealers to give warranty on the machinery and assurance of spare parts supply for a certain period. This is an example of internal enabling environment required for stakeholders in the supply chain.

Implication of CARD Approach on Rice Mechanization in Ethiopia

During my stay in Ethiopia in 2013, I visited some agricultural machinery producers, dealers, rice millers, farmer groups, and NGOs working in the rice mechanization sector. Accordingly, here are my observations;

Mennonite Economic Development Associates (MEDA), an NGO supports rice farmers in Amhara Region especially in Fogera rice producing area with financial support from the Canadian International Development Agency. MEDA tries to establish and strengthen rice value chain relationships linking small farmers with agribusiness and profitable markets. As a part of their activities, rice mechanization is tried by farmers from planting to processing. Farmers are eager to use row planters, manual weeders and reapers, but not threshers and containers. It is a very simple principle that farmers do not mechanize what they do not feel merits over the cost besides technical difficulties. The good part of their approach is to reduce subsidies to farmers from introductory price. In addition, MEDA encourages local engineering company to produce rice parboilers and weeders.

The Kohar Michael Women's Group established in 2008 started a rice parboiling business with support from the Sasakawa Africa Association. They use parboiling vat heated by firewood. It requires less cost, but the quality of

parboiled rice is not stable. They have their own package to sell their products, but their capacity to link with the market is still weak and their potential is not fully utilized. Improving their market channel could be an option to expand their business.

AMIO Engineering is an agricultural machinery fabricator and dealer in Addis Ababa, selling imported machines from China and domestically produced machines such as threshers. They foresee a great demand of reapers in the country. However, there will be limited demand in tillage machinery due to widespread animal draft power and its comparative low price of hiring a service. For their production unit, one engineer trained in Japan started to introduce 5S concept to improve the quality of production.

SELAM Technical and Vocational Center has started manufacturing rice milling machines. It is a good opportunity for students to have a chance to fabricate machines such as threshers, planters, cleaners, and mills that are commercially traded in the country from the aspect of human resource development in the agricultural machinery sector.

We have some fabricators in Ethiopia, but the quality of their products is not assured. Warranty by manufactures or quality certification by the government may be required to protect end users. It is inevitable for end users to access credit to purchase quality machines. This kind of enabling environment is necessary for the government to promote agricultural mechanization.

For rice mechanization in Ethiopia, we have to pay more attention to its unique use of rice in the food industry. The main objective of rice production is to use rice as an extender of Enjera. It means that whiteness is more important than grain breakage and criteria for rice quality are quite different from other societies. The quality requirement for postharvest operations is determined by the market. If it is globalized and integrated into the world market, rice postharvest industry will follow the development process seen in other economies.

Ethiopia is a country that successfully promotes animal draft power for farm operations. The success in animal power use may prevent engine-powered mechanization for some time, but mechanization will follow continuous economic development. There are many extension workers and farmer training centers, in Ethiopia, which is an advantage in the agricultural system. . This network can be highly utilized when operator training and support services are required.

Conclusion

Japanese success in agricultural mechanization was brought by strong government leadership in policy and legal support to fulfill enabling environment. Agricultural Foundation Law set the framework for modernizing agriculture. Agricultural Mechanization Promotion Act enabled farmers to access better quality machines, and simultaneously Agricultural Modernization Fund Act provided credit to service providers and end users to purchase high performance machinery. Further, Land Improvement Act provided farmers with better infrastructure to use efficiently agricultural machinery. Thus, rice mechanization was fully achieved by 1980s having transplanters and combine harvesters. This was possible because Japan was one of the leading industrial countries before World War II. It is necessary for African countries to develop a policy that balances domestically produced machines and imported machines for efficient agricultural mechanization.

Majority of African farming has been considered subsistence and dominated by small-scale farmers. Agricultural mechanization has stagnated at the lowest level among small-scale farmers in SSA because they do not have enough purchasing power of machinery with cheap labour force in the sector. However, favorable economic conditions are appearing in Africa, such as the continuous increase of real GDP and investment in-flow, as well as high price of major cereal crops. In addition, the agricultural machinery price is being lowered by producing them in developing economies. African market has been integrated to the global market, and agricultural mechanization has become more real. It is the right time to revitalize agricultural mechanization programs to enhance agricultural production and to re-invest in agriculture.

With increased investment in agriculture, in the SSA the market scale of agricultural machinery is also enlarged. The demand of farmers and the motivation of suppliers are consistent under the current circumstances. Many pre-conditions to promote mechanization can be met by actively solid investment in agriculture. It can create a situation that is profitable for all stakeholders in the machinery supply chain, namely farmers, machine owners, machine operators, machine suppliers, and manufacturers. This situation can be strengthened if Private-Public-Partnership (PPP) is led by the government in favor of promoting agricultural mechanization.

In Ethiopia, rice industry is at the dawn of mechanization. If rice consumption is diversified and demand of consumers on rice quality is improved, the rice value chain is linked and the rice industry will grow from postharvest operations. It is anticipated that Ethiopia can boost rice mechanization once the rice industry starts to be on the move.

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