27 Mechanizing Africa's Rice Sector

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Introduction

Significant increases in rice production can be obtained in sub-Saharan Africa (SSA) by increasing rice grain yield in existing production systems, expanding rice harvested area, and reducing harvest and postharvest losses. However, availability of labour at critical times is often a major constraint, and this situation is aggravated by the effects of the HIV/AIDS pandemic. Delays during harvesting, threshing and drying cause losses in both grain quantity and quality. Rice crops in Africa are often not planted on time due to late and poor land preparation as farmers wait for rain to soften the soil so they can prepare the land using hand implements. This often results in poorly prepared and uneven seed beds and weeds become a major problem. To compensate for this, farmers tend to plant more seeds. Late-planted crops are more susceptible to pest damage, in particular leaf diseases. Unlevelled and uneven fields result in higher water requirements, poor fertilizer-use efficiency and non-uniform crop ripening causing delays at harvest and increased losses to shattering and birds. Rainfed rice crops are often left in the field up to one month longer than necessary because farmers tend to wait until grain moisture content is low enough for easy hand-threshing. At the other end of the scale in some irrigated systems, such as in the Senegal River delta, farmers tend to wait for large combine-harvesters to harvest their fields. These harvesters often break down and can only enter fields when the soil is dry. Such situations increase the risk of shattering and bird damage.

In general, postharvest losses of rice are very high, with estimates ranging from 30% to 50% (Mrema *et al*., 2008). In some instances, all of the grain is lost, contaminated by mycotoxins or spoiled by rain before harvest and during storage. These losses occur because of poor postharvest management, outdated postharvest technology and poor storage facilities. Losses in quality and quantity combined can reduce the value of the milled rice by 20–50% at the market, thus further reducing farmers' income and providing consumers with poorer-quality rice. In addition to these losses, there is also a loss in potential income by selling the grain at the point of harvest. If farmers are able to safely store their grain, they can often increase the value of the grain by 30% in the 3–4 months after harvest. Rice production in SSA in 2010 was estimated at 18.4 million tonnes (Mt) of paddy (AfricaRice, 2011). Assuming a conservative 20% of postharvest losses, reducing postharvest losses by half would provide an additional 1.84 Mt

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of paddy, equivalent to 10% of regional imports, with a value of about US$550 million per year.

Overcoming labour shortages requires labour-saving technologies and practices, and injecting energy into the farming system through mechanization (Mrema *et al*., 2008). Agricultural mechanization aims at 'reducing human drudgery, increasing yields through better timeliness of operations because of the availability of more power, bringing more land under cultivation, enabling agriculture-led industrialization and markets for rural economic growth, and ultimately improving the standard of living of farmers' (FAO and UNIDO, 2010). Management practices along the entire rice value chain 'from farm to plate' can be mechanized, i.e. from land preparation, through water management, weeding, pest control and harvesting, to transportation, storage and processing.

Introduction of mechanization can address labour bottlenecks, improve productivity and allow household members to pursue other activities. More importantly, mechanization may allow for intensification and increases in harvested area. For example, introduction of a small-scale combine-harvester may allow timely rice harvesting and increase opportunities for growing a second crop in the same field in one year or opening up new rice fields – creating employment opportunities and increasing farm revenues. Proper land levelling using small hand tractors or four-wheel tractors with laser-assisted equipment will enable farmers to better manage their crops and gain higher returns from inputs such as mineral fertilizer. Development of the mechanization sector itself will also create employment.

Lack of mechanization seriously limits the productivity and competitiveness of rice-based systems in SSA. This is now widely recognized and agricultural mechanization is a key component in all of the national rice development strategies that have been developed under the Coalition for African Rice Development (CARD; 21 African countries; www.riceforafrica.org). There is now a clear commitment at national level to mechanize Africa's rice sector. At the same time, the continent is littered with wrecks of imported agricultural machinery, abandoned because: the technology is not adapted to the field conditions in SSA; it is of inappropriate design; there is a lack of spare parts; or maintenance is costly. Introduction of mechanization, therefore, requires careful analysis of past successes and failures, and discussion of lessons learned.

This chapter starts with a review of the status of agricultural mechanization in SSA. Next, pre-harvest, harvest and postharvest mechanization options that could make a difference in Africa are discussed. Finally, the different roles that partners need to play to enable sustainable mechanization of Africa's rice sector is illustrated, with a discussion of the outcome of a workshop on 'Boosting agricultural mechanization in rice-based systems in sub-Saharan Africa' held at Africa Rice Center, Senegal in June 2011.

Status of Agricultural Mechanization in Africa

The number of four-wheel tractors (with four wheels and two axles) can be used as an indicator of how far a country (or region) has advanced in mechanizing its agriculture. In 1961, SSA had approximately 3.4 times more tractors in use than in Thailand; however, by 2000, Thailand had the same number as the whole of SSA. These tractors were concentrated in a few countries. For example, in 2000, South Africa and Zimbabwe accounted for 50% and 17%, respectively, of the tractors in the Southern African Development Community, while Nigeria accounted for 68% of the tractors in the Economic Community of West African States (Mrema *et al*., 2008). Few of these tractors worked in rice.

Primary land preparation in SSA relies on human muscle power for about 80% of the cultivated land, with draught animals and tractors being used on only 15% and 5%, respectively. This contrasts strongly with Asia, where land preparation on over 60% of the cultivated land is done by tractors (Mrema *et al*., 2008). These figures illustrate that farm power is deficient almost everywhere in Africa, and rice-based systems generally are not an exception to this rule.

Pre-harvest mechanization: challenges and opportunities

In Africa, land preparation is done mostly by hand or animals. Power substitution by using either two- or four-wheel tractors is an obvious way to increase labour productivity and to improve the timeliness of operations. Programmes to increase the use of tractors have failed in the past because of a top-down approach to machinery selection, poor maintenance, lack of after-sales service and insufficient operator training. The two-wheel tractor enabled the mechanization of the green revolution in Asia and could also be used by smallholder farmers to do the same in Africa. Initially, the tractor would need to be imported but could eventually be produced locally, for example in joint ventures with Asian companies. The development of contract-service business models for four-wheel tractors for land preparation and other services such as laser levelling could increase the applicability of this technology. Minimum or zero tillage is not a common practice in rice-based systems in Africa.

Due to labour shortage, many farmers have shifted from transplanting to direct seeding or were already direct seeding using manual broadcasting. The drum seeder, which is a simple technology, is available for improved crop establishment in rows, which allows mechanized weeding between rows. More sophisticated direct-seeding technologies, both dry and wet seeded, are being verified in South Asia in conservation farming approaches and could be of interest to Africa at a later stage when successful experiences with mechanization are available.

If mechanical weeders are to be used, crops must be planted in rows. This will require more care and, in some instances, more time or labour at planting. However, if the planting is undertaken using a mechanical seeder, transplanter, or a drum seeder, this will not be a problem. Mechanical weeding using a cone weeder has proved to take one-sixth of the time it takes for traditional hand weeding. The type of weeder will also need to be matched to the soil as, for example, cone weeders are best in heavy clay soils and finger weeders in sandy conditions.

The majority of lowland-rice farmers in SSA level their land by moving soil from higher to lower portions of the field using a hand hoe. In large fields, farmers sub-divide the land into more manageable sizes. This practice tends to reduce the area available for planting because of the space taken up by bunds. Direct-seeding technologies such as the drum seeder, but also more sophisticated mechanized direct-seeding equipment, require improved land levelling for good crop establishment. In areas where four-wheel tractors are being used for contract ploughing, laser-assisted levelling could be added to the service provision for farmers. In India and Vietnam, laser levelling increases yields by 5–10%, reduces irrigation water requirement by 20–40%, reduces herbicide cost, produces better-quality rice and can lead to 4–6% increase of rice area if small rice fields are consolidated into bigger ones. Although the laser-hydraulic control equipment needs to be imported and appears to be expensive, when used in a contract-service business model it can be profitable for the contractor and the farmer.

Engine-driven axial-flow or propeller-type pumps can improve irrigation of individual fields if only a small amount of lift is required. These pumps usually provide flows in the range 150–1500 m^3/h, with heads in the range of 1.5–3 m. These pumps can be driven by the same engines as the hand tractors; these engines can also power stationary threshers.

Harvest and postharvest mechanization: challenges and opportunities

Harvesting

More than 70% of the rice in Africa is harvested by hand using a sickle, knife or machete. This requires a lot of labour, mostly provided by women in rainfed upland and rainfed lowland areas, and by men in irrigated environments. Hand harvesting is fraught with problems, including the time required that could be used in other activities and delays in harvesting, leading to both quantitative and qualitative losses. These losses occur through shattering, low moisture content, attack by rodents, birds and insects, grain germinating in panicle due to rainfall or lodging (panicles touch the soil).

Mechanized harvesting may involve the use of small reapers in combination with mechanical threshers, mini combine-harvesters and large combine-harvesters. Reapers were introduced for use in the rainfed and irrigated lowland environments and have not been really successful in SSA. Constraints in the use of reapers can be attributed to low capacity, less than 1 ha/day; they require an efficient operator, and spare parts may be difficult to access as they need to be imported. Reapers or cutting bars may also be mounted on a power tiller. Reapers are more appropriate for use on medium-sized farms (5–25 ha) and may be affordable for farmer cooperatives. Reapers are commonly used in the Office du Niger (Mali) and northern Senegal.

Since 2000, small combine-harvesters have been introduced from China, India, Japan and Thailand. While they can harvest 2–5 ha/day, their introduction has not been successful because of the higher level of sophistication of the technology, lack of trained operators, poorly prepared and unlevelled field conditions, lack of spare parts and maintenance, and the high initial investment required by small-scale farmers. These challenges are now being addressed by introducing smaller and cheaper 'mini-combines' with less sophisticated technology that may be fabricated and maintained locally. The major parts that need to be imported are the gearbox and drive belts. The local fabrication of these mini-combines will help ensure employment and incomes for the fabricators or local artisans, maintenance-service providers, spare-part fabricators, and others.

Large combine-harvesters capable of harvesting 5–10 ha/day are mostly used in the large irrigation schemes in Egypt, Mauritania and Senegal. In Senegal, only 29 remain in working condition out of the initial 41 introduced (SAED, 2010), They are suitable for large farms but need well-levelled fields to function efficiently. These combines are very expensive, often costing more than $100,000, tend to break down often, and spare parts are not readily available. Consequently, their use is much less now than in the pre-structural adjustment era and often those now being imported are second-hand machines.

Threshing

Threshing is done either manually or mechanically using a pedal or motorized thresher. Manual threshing involves hitting the panicles against a stationary object (e.g. drum, log of wood, wooden box), beating the cut crop with a stick, or running animals or a tractor over the cut panicles to remove the grain. Manual threshing is popular because of its low cost; however, quantitative and qualitative losses can be as high as 20–30%. This is especially a problem with excessively dry or wet panicles. Manual threshing requires the rice straw to be cut long to allow the paddy to be more easily held when hitting against a drum or threshing board to remove the grain from the panicle. Conversely, mechanical threshing requires short straw to avoid clogging the thresher and reducing the machine's threshing efficiency.

In Burkina Faso, Guinea, Liberia, Madagascar and Sierra Leone, hand and pedal threshers have been widely adopted. They are now built locally and are used by small-scale farmers as well as for seed producers. These machines have a threshing capacity of 500 kg/day, and require a lot of physical energy to operate. This has increased the desire within the region for mechanized threshers.

The motorized vortex thresher was introduced in the 1990s and is now widely used in Liberia, Madagascar, Nigeria, Senegal and Sierra Leone. It can thresh 400–800 kg/h and has revolutionized rice threshing in the region. The technology is very simple and the machine is now being fabricated by local companies such as Sismar and Matforce in Senegal. One of the limitations of the vortex thresher is that it does not clean the grain effectively. It also requires up to six people to operate and an additional three or four people are required to clean the grain by winnowing after threshing. This constraint was overcome with the introduction of a thresher–cleaner from Vietnam via the International Rice Research Institute (IRRI). This machine was modified collaboratively by Africa Rice Center (AfricaRice), Société d'aménagement et d'exploitation des terres du Delta du Fleuve Sénégal et des vallées du Fleuve Sénégal et de la Falémé (SAED) and the Institut sénégalais de recherches agricoles (ISRA) to suit local conditions and named 'ASI'. The ASI thresher can thresh and clean 1000–1500 kg grain/h, is operated by four people and the grain does not require winnowing after threshing. This thresher is mounted on two wheels and can be easily transported by draught animals, tractor or other vehicle. It is now fabricated locally and provides employment opportunities in many rural areas.

Crops are ideally harvested when grain moisture content is 20–22% and stored when the moisture level is less than 14%. When crops with high moisture content are threshed, some form of drying will be needed. This can be done by solar drying using the sun, or mechanical drying using some form of hot-air. Sun-drying is practised by most farmers in SSA by drying on mats, roadways or drying pads. Care needs to be taken to ensure that the paddy is not contaminated by soil or other materials when left to dry. With solar drying it is also difficult to control the rate of drying as it is difficult to control ambient temperatures. The ideal temperature is 42°C, but in many instances field temperatures are above 65°C. The depth of the paddy and the duration of drying will also affect grain quality and may result in high levels of grain breakage and low milling yields when processed. This problem can be reduced by turning the grain every hour, and tempering the grain by alternating between sun drying for a short time period and then allowing the grain to cool in the shade. Stacking of moist rice crops for more than 24 h after cutting may cause grain discoloration and spoilage. To avoid this, wet crops need to be threshed quickly after cutting, and then dried as soon as possible. This may be difficult to achieve when trying to sun dry rice harvested in the rainy season.

In these situations hot-air mechanical dryers are an alternative. Small flat-bed batch dryers have been tested in some countries, but they are not popular in Africa because they are expensive to operate and have limited capacity of 2–3 t/day. Rice husk furnaces are now available that can provide hot air for flat-bed and batch dryers. These will reduce the operating cost and use husk (a milling by-product) as the source of energy. Column dryers are used in large-scale mills, but high throughputs are needed and the high cost of fuel is often prohibitive.

Milling

The type of rice mill, the quality of the paddy, postharvest handling, the rice variety, and the miller's skill all influence milling performance. Good-quality paddy processed in a multi-stage rice mill can yield 65–70% of white rice (milling recovery) and 50–60% whole grains (head rice).

The ideal grain moisture level for milling rice is 12–14%. In the Senegal River valley, paddy harvested at the end of the wet season, may have a moisture content (MC) of 10–12%. This moisture content lasts for approximately one month, after which the paddy moisture drops below 10%. This is due to high ambient temperatures during the day, extended drying times and poor storage conditions. Over-dried paddy is more susceptible to breaking during husking and whitening, and this results in reduced white-rice and head-rice yields. Poor postharvest handling of the grain also causes grain breakage (Moreira, 1993; ODI, 2001). When very dry rice is stored it can absorb moisture from the surrounding humid air which may also increase cracking or fissuring in the grain resulting in low head-rice yields. In the Sahel, milled rice often contains 10–20% head rice, 30–40% large broken grains and 30–60% small broken rice (Moreira, 1995; ODI, 2001). Aoki and Seck (2011) also demonstrated the effect of low MC on milling recovery of the irrigated crop harvested in December in Senegal. The reverse occurs with rice harvested during the rainy season in July–August. High grain moisture contents of 15–18%, caused by high humidity and early rains, result in low milling recovery of 55–60%, powdered rice and frequent breakdowns in the mill. These conditions may also act as a constraint to double cropping in the Sahel.

In many rainfed rice areas in West Africa, paddy rice is stored in drums, either metal or plastic, in mud granaries or in the open-air kitchen, and then processed as needed using a pestle and mortar. This type of processing does not remove the bran layer and leaves most of the rice as broken brown rice and husks. For local commercial milling, steel huller mills, often referred to as Engelberg mills, are used. The Engelberg mill often results in yields of 55% white rice and 45% of a mixture of bran and powdered husk, with the latter being used to feed livestock. The cost of milling using this type of mill is CFA 600–1000 ($1.1–1.9) per 80 kg bag of paddy. Many of these steel huller rice mills are now fabricated locally and are widely distributed in SSA.

Surveys from the Office du Niger (Mali; Cruz, 2001a,b), Senegal River valley (SAED, 2010), Guinea (Norsa, 2011) and Cameroon (ODI, 2001) highlighted a large number of Engelberg mills which were originally imported from Europe and China, and also some locally fabricated machines. In 2000, there were more than 700 of these mills in Mali and 350 in Senegal. In Guinea in 1995 there were 200 Engelberg mills and this had risen to 900 by 2003. However, milling rice with an Engelberg mill results in very high percentage of broken rice and low milling recovery. Milling recovery can be less than 55%, which is already 10% below the expected average. This 10% loss is caused by broken rice ending up in the bran and husk.

Two-stage milling, which incorporates a rubber-roll dehusker and a steel polisher for whitening, is also popular in villages and for small-scale commercial milling. These mills can process 250–750 kg of paddy per hour. The rubber rollers remove the husk from the brown rice and then an abrasive or friction polisher removes the brown layer or bran. The brown layer does not contain the powdered husk as in the case with the Engelberg. This type of mill gives a better-quality rice and a higher milling recovery than the Engelberg mills. These mills are not fabricated locally and all spare parts (e.g. the rubber rollers and sieves) must be imported. These components will often need to be replaced every 60–80 tonnes of milled rice if quality is to be maintained.

Rice being processed in small village mills is often a mixture of different varieties and kernel sizes. Because these mills lack paddy-grading facilities they have difficulty competing in quality with imported rice or rice processed by the larger multi-stage commercial mills. Large commercial rice mills pre-grade paddy and milled rice, and in some instances often colour-sort milled rice.

A mechanical grader, with double screens to separate whole and broken grains, was introduced into village mills in Senegal by the Taiwan Agricultural Corporation. This type of grading equipment could be built locally and would make a tremendous improvement to the quality of the final product if adopted in SSA for small village mills which use the Engelberg or two-stage mills.

Multi-stage commercial rice mills, capable of milling 1–2 t/h, are also used in Africa. These mills have separate components for pre-cleaning, husking, whitening and polishing, grading and packaging. In some mills, the milling equipment is not complete, as they lack paddy cleaners, destoners, paddy separators and grading equipment. One way to improve the quality of milled rice has been to grade the rice in two operations. The first operation uses a rotary sifter to separate large grains from small grains, and the second uses an indented cylinder to separate whole grains from large broken grains.

Business models

Mechanization requires equipment to be produced, distributed, serviced, financed and bought by the end-users, who then need to ensure that they make a return on their investment. This means that valid business models are needed for selecting mechanization options, the production and delivery of the machines to the end-users, and provision of support services.

Most schemes for public hire and cooperative ownership of equipment have been unsuccessful worldwide. Business models that have been successfully used include private hire service through contract service providers, private ownership for their own farm and hire-out services for excess capacity, exclusive private owner–user and informal joint ownership (Rijk, 1986). In SSA, particularly in francophone countries, the liberalization of the rice sector and the introduction of agricultural banking led to the establishment of agricultural services providing inputs such as seed, herbicides and fertilizers, land preparation, mechanical harvesting and threshing. Governments completely withdrew from these activities, which were taken over by the private sector, which also took the lead by importing equipment.

Agricultural banks are willing to support the mechanization of the agricultural sector. For example, the West African Development Bank (BOAD) has established a CFA 4 billion ($7.6 million) fund to support the private sector in providing mechanization services to farmers.

Researchers can help to scale out feasible mechanization options by identifying and supporting suitable business models and by providing assistance in business planning. A business plan is required when seeking financing or applying for a loan. Financing institutions are usually risk averse and do not like agricultural credit because of their lack of understanding of the agricultural sector and lack of land tenure and ownership. Business plans can be used to engage with financial service providers with a view to designing custom credit lines for agricultural equipment.

The development of business models for the manufacture and supply of agricultural equipment and service provision is the responsibility of the private sector. However, there is often heavy bureaucracy in granting business permits, high taxes and duties, and other constraints. It is the role of the public sector to create a favourable business environment so that the private-sector players can fulfil their roles. Researchers can assist this by engaging in a policy dialogue and lobbying for a better policy environment.

Can Lessons Learned in Asia Help?

Mechanization of rice production and postharvest processes started in South-east Asia with the promotion of two-wheel tractors, and the development of the axial-flow thresher and low-lift axial-flow pumps in the 1970s. By 2012, land preparation and threshing were fully mechanized in most intensive rice-production systems across Asia. A second wave of mechanization started in the mid-1990s with the development of combine-harvesters in Thailand and Vietnam, and the introduction of laser-assisted land levelling using four-wheel tractors in China, India and Vietnam. The adoption of mechanical dryers started in Thailand and Vietnam in the 1990s and, since the early 2000s, IRRI has facilitated the spread of simple flat-bed dryers, using rice husk as fuel, in Cambodia, Indonesia, Laos, Myanmar, Philippines and Vietnam. More than 80% of the rice in the Central Plains of Thailand is harvested by combines, and there are more than 6000 combines in Vietnam and about 2000 in Cambodia, a country which did not have a single unit in 2007. In India, more than 10,000 contractors provide laser-levelling services. An estimated 6500 flat-bed dryers are used in the Mekong Delta and dryer numbers are rapidly increasing in Cambodia, Indonesia and Myanmar. A 'lessons learned' workshop held in Los Baños (Philippines) in May 2012, with public and private stakeholders and project partners looking at successes and failures in mechanization and postharvest, identified the following factors that led to successful adoption of such technologies:

- Identification or development of appropriate technology options that address end-users' needs, accompanied with adaptive research and development to match the technologies to local needs. This includes proper targeting of end-users – there needs to be a business model for the end-users if the technology is to be applied successfully.
- Private-industry involvement at a very early stage of technology development and dissemination, including local manufacturers, distributors and international machinery companies.
- Private entrepreneurship as the most efficient way to apply and provide mechanization technology, e.g. though machinery contract and hiring services, distribution, and repair services.
- In all successful cases of technology introduction there has been at least one technology champion, who was committed to move the technology forward against all initial hurdles, often supported by a local champion helping to promote the idea to potential users, intermediaries and policy makers.
- Sufficient time horizon for projects that aim to introduce a new technology. The introduction of the axial-flow threshers, combine-harvesters and mechanical dryers in South-east Asia and laser-levelling equipment in India took at least 6 years of support to achieve significant initial adoption that led to sustainable introduction.
- Successful initiatives had some sort of multi-stakeholder platform that embraced the different stakeholders from public and private sectors.
- Policy dialogue for creating an enabling environment for the industry and also for lobbying for support of promising technologies through the government extension service and the provision of support services (e.g. agricultural credit).

Often many well-intended initiatives failed when they included machinery importation or manufacturing by public-sector institutions, top-down decision making on technology choice, subsidized machinery distribution, lack of financing or lack of supporting policy. Machinery use through public hire services, farmer groups or cooperatives instead of service provision by private contract-service providers has been unsuccessful in South-east Asia.

While technologies as such are not necessarily transferrable without modifications, these Asian experiences with approaches and methodologies for fostering mechanization can provide some lessons for new initiatives in Africa.

Towards Sustainable Mechanization in Africa

In June 2011, representatives of national agricultural research systems and local manufacturing and distribution companies from seven countries (Ghana, Mali, Nigeria, Senegal, Sierra Leone, Tanzania and Uganda), farmer organizations, rural credit providers, international research and development organizations (AfricaRice, IRRI, JICA, CIRAD[1]), international agricultural machinery manufacturers (Briggs & Stratton) and CARD discussed opportunities to boost agricultural mechanization in rice-based systems in Africa in Saint-Louis (Senegal). A total of 47 participants attended. The workshop also looked back at successes and failures in terms of agricultural mechanization.

One success story in particular was highlighted: the development of an axial-flow thresher–cleaner in Senegal in the late 1990s based on a design imported from Asia (Donovan *et al.*, 1998; Wopereis *et al.*, 1998). Ten years after its release in 1997, the ASI thresher–cleaner was adapted and in use in six West African countries: Senegal, Mauritania, Mali, Burkina Faso, Ghana and Côte d'Ivoire. The main reason for the success was the establishment of an alliance by AfricaRice between researchers and local agricultural manufacturers. This alliance tested a first prototype imported from Asia via IRRI and adapted it to local conditions. This process meant that the locally built machine could be entirely constructed and manufactured locally, and only the engine needed to be imported.

A similar approach is being used by AfricaRice to develop a local version of a small combine-harvester based on a prototype built by the Philippine Rice Research Institute imported via IRRI. The machine was tested and adapted in the Senegal River valley in northern Senegal during the 2011 growing seasons. In particular, the imported machine became blocked by the tougher Sahel rice straw, so a local manufacturer reinforced the cutting system, and improved the thresher wheel and elevator. After demonstration to farmers, the machine was also adapted to four wheels from the original three. This 'mini-combine' can harvest 1.5–2 ha of rice per day, requiring just three operators to do so. This is at least double the speed of hand-harvesting and ASI threshing, which takes four labourers to complete. Demonstrations to date have shown losses of just 2% and that the machine produces very clean paddy. The payback time on the investment of CFA 4 million ($7620) in such a machine is estimated at 3.5 years on the basis of harvesting 45 ha/year.

Referring to these successful examples, workshop participants stressed the need to avoid massive importation of agricultural equipment without proper testing and evaluation before large-scale release. Governments and national and international research institutes have an important role to play here. Policies also need to be developed with regard to importation and taxation that are supportive of equipment importers, dealerships and local manufacturers. Rules currently vary according to whether it is the whole machine, spare parts or raw materials that are being imported. Tax on new farm equipment can be as high as 35% and on spare parts more than 60%. Where exemptions can be claimed, the tax usually has to be paid up front and then reclaimed – it can take 1–2 years to get the reimbursement. In addition, clearance time at the ports is often very slow resulting in extra demurrage charges being levied.

Governments need to take care that they do not 'over-subsidize'. In Thailand in the 1990s, over-subsidization led to a large number of unviable two-wheel tractor and machinery manufacturers glutting the local market. When subsidies were withdrawn, the number of local manufacturers dropped from more than 150 to just a handful.

Governments also need to be responsible for the certification of equipment and provide support to training institutes. Vocational training institutes need help to develop curricula and provide training for farm-machine operators, mechanics and artisans. This training needs to include technical and business planning and management. Government and private-sector extension officers also require training to support and extend mechanized agriculture at farm level.

Credit institutes require encouragement to structure loans that suit individual farmers and contract-service suppliers. Many micro-credit suppliers work within a restricted radius around their local branch and lend to groups rather than individuals. They also have prepayment rules, often monthly, that make it difficult for farmers to comply. In most localities, interest rates are above 25% and the repayment times less than one year. Many African farmers already work in associations or cooperatives, so collective ownership could be a solution for purchasing equipment in the short term. However, problems always arise in the management and prioritization of communally owned equipment and, eventually, local entrepreneurs will need to be found to offer contract services for activities such as ploughing, harvesting and milling to other farmers.

The workshop formulated the following recommendations for the different key actors to boost agricultural mechanization in rice-based systems in a sustainable manner in Africa.

Government

- Develop coherent strategies to boost agricultural mechanization, particularly in rice-based systems.
- Facilitate enhanced public–private sector collaboration in the development of agricultural mechanization in rice-based systems.
- Reduce taxes and duties on imported machinery, components and raw materials.
- Encourage the establishment of partnerships among local manufacturers to enhance the efficiency and quality of their work.
- Support national research to guide importation of machinery that is well adapted to local rice-growing conditions, effective and durable, and can be serviced and repaired locally.
- Facilitate access to credit for key actors (local manufacturers and end-users) in the mechanization value chain to sustain and increase the supply and demand for agricultural technology.
- Build and support local training centres in agricultural mechanization.

International manufacturers

- Establish direct dealerships in Africa.
- Build local capacity in the use and maintenance of equipment.
- Provide stewardship and quality assurance.
- Develop partnerships with local manufacturers to upgrade their construction capacities.
- Support local training centres in agricultural mechanization.

Local manufacturers

- Construct quality equipment or components that are adapted to local rice-growing conditions and for which local manufacturers have a clear competitive advantage.
- Provide aftersales services for products.
- Create partnerships among local manufacturers to standardize key equipment and to better respond to demands for local manufacture and maintenance of equipment.

National research and extension agencies

- Identify local needs for equipment in partnership with end-users.
- Contribute to the elaboration of policies that strengthen agricultural mechanization of the rice sector.
- Build local capacity through introduction of prototype technology in partnership with local manufacturers.
- Identify and work with key local manufacturers to help adapt prototype machinery that can be fabricated locally.
- Support training of local artisans for constructing and servicing machinery.

- Elaborate technical standards and norms for use, maintenance and manufacturing of equipment based on field testing.
- Provide advice on business planning to mechanize farming in rice-based systems to farmer cooperatives and service providers.
- Provide methods and decision support for extension agents and end-users to guide the use and maintenance of agricultural equipment.
- Provide facilities to train adequate numbers of agricultural engineers.

International research centres such as AfricaRice, IRRI and CIRAD

- Contribute to the elaboration of policies that strengthen agricultural mechanization of the rice sector.
- Contribute to enhanced public–private sector collaboration in the development of agricultural mechanization in rice-based systems.
- Introduce new prototypes for testing under local conditions based on identified needs.
- Help improve local manufacturing technologies.
- Establish a network of local manufacturers and researchers from national and international research (Africa-wide Rice Mechanization Task Force) to enhance and sustain agricultural mechanization in rice-based systems, in particular:
    - Support the development of training curricula on agricultural mechanization in partnership with key actors in Asia and Latin America;
    - Exchange knowledge on agricultural mechanization in rice-based systems in Africa and worldwide;
    - Facilitate South–South cooperation between Africa and Asia and Latin America for local manufacturers and research through exchange visits and training.

Umbrella agricultural research and development forums

- Identify local institutes that can serve as training centres in agricultural mechanization.
- Assess government policies related to agricultural mechanization, in particular with respect to the importation of agricultural machinery and spare parts across Africa.
- Advocate support for mechanization as part of national rice development strategies.

Conclusions

There is an urgent need to inject more energy into Africa's rice-farming systems. Mechanization can provide that extra power, addressing labour bottlenecks, improving productivity per unit of land and labour, and allowing household members to pursue other labour activities.

This chapter reviews the challenges and opportunities related to mechanization in Africa's rice sector, 'from farm to plate', looking at interventions before, during and after harvest. Many possibilities and opportunities exist that can, in principle, be readily exploited, copied and scaled out. However, the African continent is littered with wrecks of imported machinery. As much of the machinery as possible needs to be manufactured locally to create job opportunities, keep costs down and ensure that equipment is adapted to local conditions and can be maintained locally. More thought needs to go into business models that fit African conditions to help scale out feasible mechanization options. Much can be learned from experiences in Asia.

Recommendations formulated during the mechanization workshop in 2011 aim to prevent any repetition of past mistakes and to ensure sustainable and focused mechanization of the rice sector in Africa. Mechanizing Africa's rice sector is a prerequisite to reach the ambitious growth objectives set by African governments for their rice sectors.

Note

[1] JICA, Japan International Cooperation Agency; CIRAD, Centre de coopération internationale en recherche agronomique pour le développement.

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