Small-scale Farm Mechanization Catalogue

TAAT Clearinghouse

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Front cover photographic credits: A hand tractor converted into a trailer (Ikonic Farm Machinery (K), safe and effective threshing operations (Sasakawa Africa), a woman learns how to operate a hand tractor (Ikonic Farm Machinery) and the impressive reach of a water gun.

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A Report by the Technologies for African Agricultural Transformation Clearinghouse

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Purpose and Introduction

Small-scale mechanization is the key to reducing drudgery and increasing productivity among African farmers. For too long farming in Africa is regarded as a path to poverty rather than a profitable agribusiness. This is due in large part for dependency upon tedious hand labor, poor returns to effort and lack of investment into farming systems. A wide range of small-scale equipment is available to improve returns to labor and change this poor image of farming. This equipment include tillers, power weeders, power sprayers, soil augers, irrigation systems, multi-crop threshers and a host of other equipment that are becoming commercially available for the first time. Profitable use of these equipment, however, is not guaranteed because their use requires new skillsets, rigorous maintenance, and safety precautions. At the same time, expanded reliance upon this equipment provides economic opportunity through their distribution and service provision. This catalogue provides insight into this useful farming equipment.

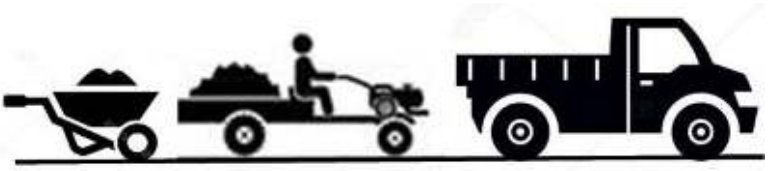
About TAAT. Weaknesses in the production and supply of commodities are viewed as responsible for Africa's food insecurity, need for excessive importation of food, and unrealized expansion of Africa's food exports. The TAAT Program led by the International Institute of Tropical Agriculture (IITA) is pioneering new approaches to the deployment of proven technologies to African farmers. TAAT arose as a common effort of IITA and the African

Development Bank (AfDB); and is an important component of the latter's Feed Africa Strategy. Currently, TAAT is advancing 100 carefully selected technologies through 88 interventions in 31 countries organized around 15 "Compacts" that represent priorities in terms of achieving Africa's potential in achieving food security and advancing its role in global agricultural trade. Nine of these Compacts relate to specific priority value chains of fish, small livestock, common bean, rice, wheat, maize, cassava, sweet potato, sorghum, and millet. Together these Compacts design interventions in collaboration with national programs to introduce technologies and innovations that are designed to meet ambitious targets for agricultural development.

About ProPAS. The Product Platform for Agricultural Solutions (ProPAS) provides a mechanism to compile and access innovations and manage technologies and products needed for Africa's agricultural transformation. The platform provides two pathways: it permits users to enter their proven and promising solutions into a database, and then encourages others to sort through its options to reveal a suite of opportunities that can assist their agricultural objectives. ProPAS results from the recognized need by IITA to more systematically compile the full range of agricultural solutions available to modernize and transform African agriculture. Many solutions are available to improve and modernize Africa's food systems, but many beneficiaries are too often unaware of the best options at hand. In addition, multiple solutions are in the research and development pipeline that can best be advanced through wider exposure and validation. Solution profiles are submitted by technology holders, compiled into a user-friendly software platform, and released in a systematic manner for use by an expanding base of clients.

The TAAT Top 100 Technologies. The Clearinghouse developed a database of the Top 100 Technologies that are transforming African agriculture. It is based upon the approaches of the TAAT Commodity Compacts but also includes those from the CGIAR Collaborative Research Programs that are recently described as ready for next user. These technologies are divided between those involving improved genetics and plant and animal breeding (23%), those based upon the distribution of digital information (3%), production input products of proven efficacy (21%), crop and animal management technologies of utility within agricultural extension messaging and campaigns (27%) and the availability of appropriately designed labor-saving equipment (26%). These technologies have a direct role towards the achievement of the Sustainable Development Goals in relation to farm productivity, food security and hunger reduction, responsible food consumption, improved household nutrition and diets, economic growth, climate-smart innovation, partnerships for the goals, and improved human equity and empowerment.

The Top 8 Mechanization Technologies. This catalogue presents eight technologies that serve to mechanize and automate small-scale farming. These technologies include: 1) Hand tractors for land preparation, 2) Mechanized weeding operations, 3) Power sprayers for agrochemical delivery, 4) Land augers as an innovative labor-saving tool, 5) Drip irrigation for efficient water use, 6) Water guns for cost-effective irrigation, 7) Multi-threshers for efficient post-harvest processing, and 8) Forage choppers in livestock feed systems. Details on each of these eight technologies are included in the catalogue. Also included is information on the safe handling and maintenance of these equipment.



Technology 1. Hand Tractors for Land Preparation

Background. A power hand tractor is a small two-wheel device powered by a small petrol or diesel engine ranging in power from 5-18 horsepower. These machines are most often attached to a rotavator that allows for land tillage, but other attachments are available, including those that create furrows. These tractors are guided by handlebars that provide control over their direction and downward force and accompanying throttle to guide engine speed and a release to disengage the engine from the rotovator. The most powerful hand tractors can break new ground and dry heavy soils, while the least powerful ones are best suited to preparing previously cultivated soils. These machines are different that riding tractors with two axils that are generally 50 hp or greater. There are many brands of these two-wheel tractors and reference to them includes terms such as "rototiller, walking tractor, mechanical ox, and single-axle tractor".

A 12 hp diesel-powered tiller with adjustable tine attachment

Advantages and Disadvantages. Hand tractors reduce the drudgery of hand tillage, a practice closely associated with the drudgery of small-scale farming. Because of their smaller size and tight turning area, hand tractors till areas that cannot be accessed by larger tractors, including lands with steeper and irregular slopes. Hand tractors are powered by a single axil (gear only), so there are no additional belts or chains, improving their reliability and reducing maintenance requirements. It is unlikely that a farmer managing only one hectare or so can afford a riding tractor, hand tractors available for US $700 to $3,000 are much more within reach. A single operator can prepare a hectare of land in a single day using this machine. Many models have attachable tines that allow for adjustment in cultivation width, allowing for use as a weeder at wider crop spacing. Some tillers can be used in flooded paddy soils as well, allowing for the incorporation of residues and inputs.

Different attachment options; harrow (top), rotovator (center) and paddy wheel (bottom)

Maintenance is fairly easy, unlike larger tractors that require skilled mechanics. One must regularly check oil and fuel levels and ensure that dirt does not accumulate on the engine during use. The depth of tillage is less than a riding tractor and these machines may form or prove unable to break through hard pans that form in clayey soils. The times of tillers may become clogged by rocks or soil clods, forcing temporary shut down during safe removal.

Options and Specifications. Hand tractors are available with either petrol or diesel engines ranging in size for 5 to 18 hp, with more powerful units offering greater capacity. The machines allow for a range of operations including seasonal ploughing, harrowing, and forming beds, and later in the season for weeding between crop rows and in orchards. In addition, hand tractors may be attached to trailers to transport goods and people.

Power (hp)	8	12	18
Tillage depth (cm)	25	30	40
Tillage width	90	110	140
Work capacity (ha/day)	1.0	1.5	2.5
Fuel requirement (liter/ha)	10	12	15

Availability and Commercial Opportunity. A wide variety of hand tractors are becoming available across Africa. A quick review of available products suggests that they are mostly imported from China with other models from India and Europe. A quick review found numerous suppliers and products available in Kenya, Ghana, Nigeria, and Uganda. In other countries, such as Zambia and Zimbabwe, the market remains focused upon smaller four-wheel tractors targeting emergent commercial farmers rather than "walking tractors" possibly due to larger average farm sizes. In many countries, internet search for suppliers immediately leads to overseas importers, particularly China. A search of Chinese suppliers revealed over 15 manufacturers of hand tractors ranging in size from 8 hp to 22 hp, with larger models having additional features such as seats and headlights. One advantage to importation is the lower prices, with smaller models available for as little as US $200. A disadvantage is the requirement to meet minimum orders and the time and logistics for importation.

A top of the line two wheel tractor available in China, note that it includes a seat for the operator

Clearly, opportunity exists to engage in the trade, sales, and servicing of hand tractors as their popularity and accessibility grows. Companies specializing in the wholesale importation of these machines and their attachments are needed to meet growing demand, and the competition between such companies will bring prices down. Opportunity exists to design attachments that better meet small-scale farming needs, and for decent employment through the assembly and maintenance of these machines. Ideally, agrodealers will begin to market these machines within their shops as well. Finally, land preparation using hand tractors will be offered as contract services by local operators to reduce drudgery among a growing number of small-scale farmers.

Technology 2. Mechanized Weeding Operations

Background. Weeding is performed after sowing but before harvesting the crop as a means of reducing the competition from unwanted plants. While uprooting these unwanted plants, other benefits occur such as better aerating the soil, promoting the activities of microorganisms, and introducing cut weeds as mulch and soil inputs. These operations are accomplished by different means and tools, and for the most part in African smallholder systems it occurs through intense hand labor. A hand hoe consisting of an iron blade and short wooden handle is the most common weeding tool, and it is closely associated with the drudgery and continued poverty of small-scale farming.

A commercially-available backpack weeder and its different parts

A power weeder is an alternative approach to weed management through secondary tillage that greatly relieves drudgery associated with hand weeding. Two basic types of power weeders are available; ones that are worn on the operators back where weeds are cut and buried to shallow depths through arm movement (power backpack weeders) and others that resemble small walking cultivators that pass between crop rows chopping weeds and burying them to adjustable depths (mini-cultivators). The machines require skillful use and maintenance to ensure that crop plants are not injured in the process of weed removal and that the machinery remains in good working order.

Advantages. The advantage of mechanized weeding is that the control of unwanted plants is achieved without heavy field labor. This control is best achieved within a wider strategy of integrated weed management, particularly through the judicious use of pre-emergent and selective herbicides. Using mechanized weeders, it is possible for a single operator to greatly reduce weeds from 0.5 to 1.0 ha per day, particularly for field crops with widely spaced rows and in orchards with open space between perennial plants. An advantage of mechanical weeding is that operators need not wear heavy protective gear other than boots and in some cases dust masks. One disadvantage to mechanized tillage is when rocks or soil clods clog the rotating blades, causing the machine to be temporarily shut down for the blockage to be cleared. Another difficulty is the cost and the inability of poorer households to afford them.

Options and Specifications. As stated above there are two basic types of power weeders; backpack weeders and mini-cultivators. A typical backpack weeder consists of a petrol engine and small fuel tank mounted onto a padded backpack frame connected to a flexible power hose leading to a handle ending in different replicable power heads bearing either rotating or circular blades. The handle is controlled with grips that also allow access to an on/off switch.

Two commercially-available mini-cultivators useful for weeding widely spaced row crops as well as smoothing unevenly tilled fields and preparing horticultural raised beds

The small petrol-powered engine (e.g., 35 to 50 cc) is air cooled and intended to operate at a continuous speed without overheating. These machines weigh between 6 and 9 kg and allow operators to weed up to 1 ha in a day using only 2 liters of fuel. Because the rotary blade sits upon and digs into the soil there is little arm fatigue during its use. Use of this machine is 10-fold more labor efficient compared to hand weeding with a hoe. An advantage to this machine is the wide range of different heads that can be affixed to it that may be used for cutting brush, levelling tilled fields, harvesting field crops, and even powering small water pumps. These units are available at a cost of US $240 to $380 each, depending on the size of the engine and the number of different heads included with the purchase.

Mini-cultivators are fundamentally different machines that serve a similar purpose in terms of weeding, but lack the wider utility of the other backpack attachment heads. A small petrol or diesel engine (e.g., 2 to 3 hp) is mounted onto a wheeled frame that leads to handlebars at one end and rotating tines at the other. In general, these blades are 17 to 25 cm in width, incorporate materials to a depth of only 2 or 3 cm and weigh about 20 kg. While most of these machines are intended for single, well-spaced rows, modified versions allow for 2 or three closely spaced rows of vegetable to be weeded as well. Note that smaller hand tractors with adjustable tines may be used for this purpose but generally clean wider paths and dig to deeper depths. Either wheels or the rotating tines may serve as traction to pull the cultivator forward along a course determined by the operator's use of the handlebars. Some models include tail "anchors" that affect the depth of soil disturbance. Note that the tines must be set between rows with sufficient space away from plant stems to avoid any damage to plants. In general, these machines are available at a cost of US $200 to $300 each.

Availability and Commercial Opportunity. Neither backpack weeders or mini-cultivators are widely available, although some local suppliers operate in Kenya and Nigeria. Mini-cultivators are more widely available than backpack weeders, in large part because they are included among the product lines alongside larger hand tillers. In many cases, inquiries over the internet that specify African suppliers end up with manufacturers and exporters in China and India. A quick search of the Alibaba website revealed 30 different models available for sale, evenly divided between backpack and mini-cultivator types, costing between US $60 and $700 each, with backpack models generally costing less and mini-cultivators suitable for rice paddies being most expensive. The variety of different weeding heads available as attachments to backpack models is impressive, with one manufacturer offering nine different rotating blades and 10 different cutting blades for their single 52 cc petrol-powered model. Commercial opportunity exists for the importation, sales and maintenance of these machines, and rural operators can offer their use as contracted services.

Technology 3. Power Sprayers for Agrochemical Delivery

Background. In agriculture, a sprayer is a piece of equipment that is used to apply herbicides, pesticides, and fertilizers on agricultural crops. Sprayers range in size from portable units, to towed sprayers that are connected to a tractor, to self-propelled units similar with boom mounts many meters in length. Backpack sprayers are extremely useful in agricultural applications, particularly for more effective application of pesticides, herbicides, and foliar fertilizers. There are three basic options available to farmers, manual pump action, electric and petrol-powered sprayers with this section dealing with the latter type. Power sprayers are particularly useful because of their even discharge and longer reach. Equipped as an ergonomic backpack, these machines are easy to carry and use, but their greater delivery capacity requires that they be used with additional skill and caution. Two alternative power sprayer options are available: backpack sprayers or trolley sprayers. With backpack types the operator moves around with the tank containing the applied solution, and with trolleys the spray is delivered by a long hose. Both types of sprayers have small petrol engines that are ideal for continuous duty and can operate non-stop for several hours. The pressure is adjustable to various spray patterns, guaranteeing thorough distribution of droplets across large areas. These machines are particularly useful for combatting insect invasions like the Fall Armyworm and the Yellow Dessert Locust.

A commercially available backpack power sprayer

Advantages and Disadvantages. Backpack power sprayers are simple in design, easy to fill and clean, and affordable, with power sprayers available for between US $200 and $300. They are most useful for spot treatment and for spraying smaller fields or orchards. Note that uniform delivery is affected by travel speed, nozzle type, and spray pressure and requires that operations calibrate their approaches. Three rules of application accuracy apply: maintain a uniform walking speed with faster travel speed resulting in a lower application rate; maintaining an even spraying pressure resulting in constant application rate and droplet size uniform during the application with lower pressure leading to reduced flow and larger droplets; and maintaining a spraying distance between the nozzle and the target. Travel speed varies with walking pace and the physical stamina of the operator, as well as the topography of the area. Most smaller sprayers do not have pressure gauges and if the pump is pressurized excessively, the application rate will be increased while creating smaller drift-prone droplets, resulting in greater waste of pesticides and poor control of pests. It is difficult to keep the nozzle height uniform throughout the application due to arm fatigue; one technique is

A commercially available trolley sprayer (without its accompanying 50-liter tank)

to swing the nozzle in a steady, sweeping motion to minimize this effect. The greatest advantage is that the application of sprays is directed by a human who is in a better position to exercise caution when applying potentially dangerous materials to agricultural crops and cultivated lands.

Options and Specifications. As stated earlier, there are two basic types of power sprayers: backpack and trolley. A backpack sprayer typically has a 16 to 25 m tank containing spraying solution, a 33 to 50 cc petrol engine and 0.5-to-1.0-liter fuel tank, and a short hose ending with adjustable wands or spray guns. In general, this machine weighs 10 kg and can deliver sprays about 5-times more rapidly than pump action backpack sprayers, covering about 0.5 ha per hour. A trolley sprayer is mounted on a wheeled frame consisting of the 50-to-200-liter tank, 3 to 6 hp pump, a fuel tank and up to 50 m or so hose, usually mounted on a reel. The trolley remains stationary while the operator deploys the hose, delivering up to 25 liters of stray per minute. One disadvantage is that operator movements with the trolley hose are more limited, and care must be made not to injure plants as the hose is deployed and moved. An advantage of trolleys is that they may be fabricated using local materials and customized to specific needs. Both types of strayers require calibration to be used properly.

There is a three-step method to calibrate these sprayers. Step 1 measures and marks off an area equal to 500 square meters (such as 20 x 25 m). Step 2 adds a measured amount of water to the tank, sprays the area and then measures the amount of water remaining in the tank. The difference between the amount in the tank before and after spraying is the amount used per 500 square feet (= 0.05 ha). Step 3 compares the measured application rate with the recommendation on the pesticide label. If the difference between the recommended rate and the measured rate is greater than 5% of the recommended rate, adjustments are made to reduce the application error. Note that operators must wear proper safety equipment including gloves, boots, eye protection, water resistant jackets and hoods and masks.

A power spray operator in full protective gear

Availability and Commercial Opportunity. Judicious use of agrochemicals is fundamental to Africa's agricultural transformation and use of power sprayers provides a means to this end. Their use allows farmers the ability to intelligently alter application practices as conditions warrant. Compared to pump action sprayers, this equipment is not yet widely available, and this may be corrected by agricultural product suppliers stocking them side-by-side. In addition, availability of power strayers provides greater opportunity for contract service provision to farmers as a rural enterprise that in turn leads to more effective control of pests. Recent biological invasions by Fall Armyworm and the Yellow Desert Locust were met by these actors but there is scope for greater linkage to farmers. It is important that wherever these sprayers are marketed, so too is necessary personal protective gear. Agricultural extension advisers must be aware of this agrodealer linkage and ensure that precautionary messages on pesticide safety are available through it. That trolley type sprayers can be fabricated locally is also an important consideration as it may contribute to growing agro-industry, and the comparative advantages of backpack versus trolley approaches must be considered.

Technology 4. Earth Augers as a Labor-Saving Tool

A commercially available earth auger with a 30 cm screw with many practical uses

Background. An earth auger, also called a post-hole digger, is a machine used for drilling holes into the ground. It consists of an engine powering a vertical shaft that rotates screw blades that rotate to displace soil, resulting in a cylindrical hole. It is used to efficiently dig uniform fence post holes and planting holes. Holes results from a rotating helical screw blade winding around lower part of the shaft. The lower face of the screw blade progressively displaces soil from the bottom of the hole, and the remaining screw blade serves as a conveyor to lift the loose soil upward to the soil surface. When the hole achieves a desired depth and the tool is withdrawn, the blade removes any remaining soil. The rod often ends in a sharp point that keeps the auger along a straight path. The screws are available in various sized that control the width of the hole, and there are extension bits that allow for steeper penetration. A skilled operator can prepare a 40 cm deep hole 25 to 30 cm wide in less than a minute.

Advantages. The main advantage of an earth auger compared to a manual post hole digger or shovel is savings in terms of the time and effort required, and the uniformity of the resulting holes. The precise width of the holes is determined by the diameter of the screw blade and the depth may be controlled using extensions. Manually digging a series of holes results in fatigue that leads to less uniform holes with irregular shape, including sloped walls. More precise holes allow for more reliable preparation or backfill materials, whether they be cement and gravel for fence posts or enticed soil for planting holes.

Options and Specifications. A representative, commercially available earth auger includes a 64 cc, single cylinder, two-stroke petrol engine with a 1.3-liter fuel tank containing a fuel to oil ratio of 25:1. It sells for about US $230. The engine is mounted onto a metal frame with handles that allow control by the operator and ready access to its throttle. that Its drill bit length is 0.8 m but with available extension bit lengths of 0.35, 0.5 and 0.8 m, allowing for drilling depths of 1.6 m. Different drill diameters may be attached available in diameters of 6, 8, 10, 15, 20, 25 and 30 cm. A more powerful auger with a 2 hp, four-stroke engine costs US $450, including an assortment of screw blades (15, 20 and 25 cm bits). Individual replacement blades cost between US $30 and $50 depending upon their width, and extension bits are US $25 to $30 depending upon their length.

Availability and Commercial Opportunity. Use of land augers is far more common in the construction industry than among farmers, particularly smaller-scale ones. A quick survey of earth auger suppliers discovered numerous suppliers in Kenya, locally marketing several different single operator petrol powered models as both agricultural and construction equipment. In addition, other options included two-operator models with wider and deeper blades and much larger augers attached to external power sources. Local suppliers were also readily identified in Nigeria, Uganda, and Zambia, although queries for other countries suggested that local suppliers act as importers on demand. Most of these imported models were linked to manufacturers in China. A quick search of suppliers in China discovered over 15 manufactures, revealed over 25 single-operator, petrol-engine models, some as powerful as 80 cc, others available for as little as US $50 each with no minimum order, and yet others supported by a wheeled frame that guides the auger as it drills. Clearly, many options and price ranges are available to those seeking to import and distribute this equipment. Also, a 4-stroke, 196 cc, 6.5 hp two-operator model with a bit size 70 cm in diameter is sold for less than US $200 each.

An earth auger mounted onto a guiding frame manufactured in China

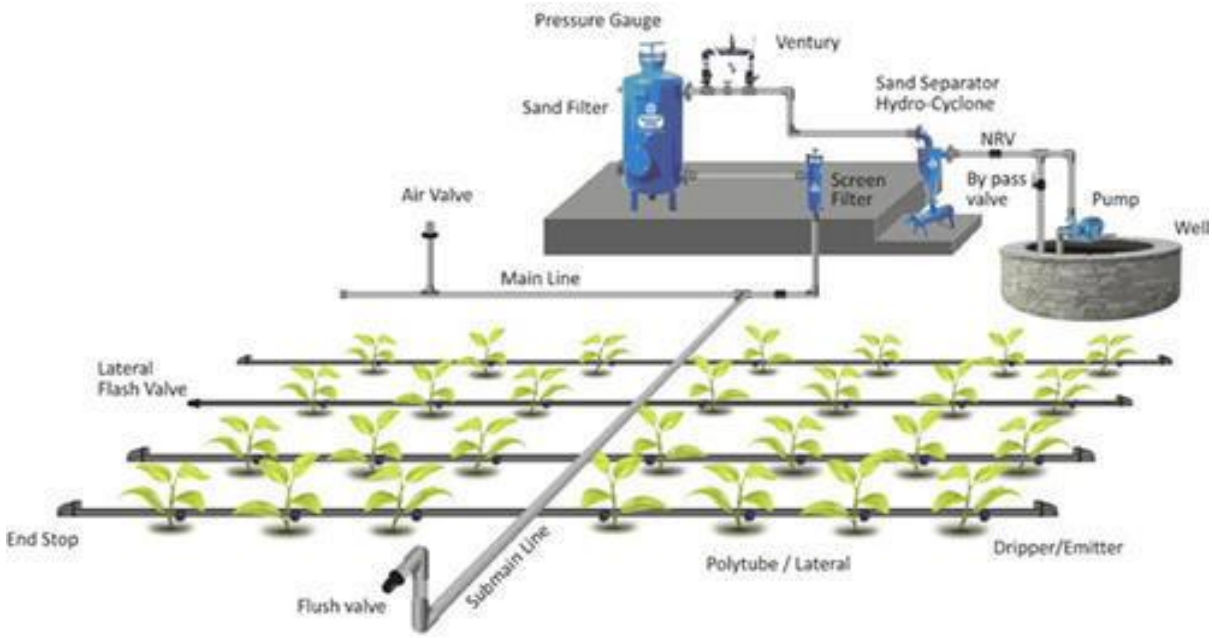
Safely operating an earth auger

An important emerging use of earth augers equipped with wider screw bits is the rapid scaping of soil pits as a water harvesting practice. "Zaï" pits are a dryland farming approach developed in the Sahel. These pits are formed by digging shallow basins of 20 to 30 cm diameter and 10 to 15 cm deep into croplands, allowing the pit to collect water, wind-driven soil particles and plant debris. Early evidence suggests that forming these pits using an earth auger rather than hand tools is at least five time faster. On sloped lands, the soil excavated from the pit is placed downslope to better permit water catchment, a step that requires use of hand tools. Note that this same technique is also used to rehabilitate crusted and degraded lands. Greater availability of earth augers used for this purpose will likely increase this practice in dryland agriculture and allow greater expression of its climate-smart features.

A network of planting pits established with an earth auger provides opportunity for labor-efficient climate-smart farming

Technology 5. Drip Irrigation for Efficient Water Use

Background. Drip irrigation is a system that slowly delivers water onto the roots of plants in a way that strategically places moisture and minimizes evaporation. It is the most efficient method of irrigating with over 90% of its water utilized by crops. It is relatively easy to install and reduces disease problems associated with wet leaves. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters that operate at a relatively low water pressure. Components used in drip irrigation include a pump or pressurized water source, a water filter and particle separator, a backflow check valve and simple pressure regulator, a distribution mainline, control valves, smaller diameter laterals (or sub-mains), and emitters that deliver water at slow rates. While complicated in design and somewhat expensive to install, the savings in water and yield improvement is substantial.



A typical design of a surface drip irrigation system

Advantages and Disadvantages. The advantages of drip irrigation include high water use efficiency with minimal leaching of fertilizers, ability to irrigate unleveled and irregularly shaped fields, and greatly reduced weed growth and soil erosion. Drip irrigation delivers its water to the crop root zone rather than the field at large. Soluble fertilizers are readily injected through water delivery. Drip irrigation does not wet foliage, reducing the risk of disease. In addition, drip systems operate at lower pressure than others, reducing their energy cost. The disadvantages of drip irrigation include its high initial cost, sensitivity of tubing to UV light, clogging of the emitters by sediment, and additional "cleanup" costs after harvest as the tubing must be rewound and stored for use. In sandy soils, drip systems may be unable to wet the soil surface for uniform germination. Most drip systems result in little or no leaching, causing salts to accumulate. Finally, pipes may suffer from rodent or insect damage, requiring replacement and increasing expenses. Because of the way the water is applied in a drip system, traditional surface applications of fertilizer are sometimes ineffective, so drip systems often mix liquid fertilizer with the irrigation water, a practice referred to as "fertigation" and resulting in substantial fertilizer savings.

Options and Specifications. A typical drip irrigation system consists of a pump unit; a control head; mainlines and sub-mainlines; lateral lines; and emitters or drippers. The system may include additional features such as reservoir tanks and fertigation injectors. The pump unit takes water from the source and provides the correct pressure for delivery into the pipe system. The control head consists of valves to control water pressure and filters to clean the water. Mainlines, sub-mainlines and lateral lines supply water from the control head to the fields and are usually made of PVC or polyethylene hose. These water delivery lines are often buried. There are two types of drip irrigation: sub-surface drip irrigation where water is applied below the soil surface, or the much more common surface drip irrigation where water is applied directly to the soil surface. Sub-surface irrigation employs narrow plastic tubes buried in the soil at a depth between 20 and 50 cm. The tubes are either porous throughout or are fitted with regularly spaced emitters. Major difficulties with this approach are the narrow orifices of the emitters that may become clogged by roots, soil particles and precipitating salts; and that tillage practices become complicated. As this approach is not very common it is not considered further.

A small greenhouse equipped with drip irrigation

Surface drip irrigation is much more common and uses a variety of drip emitter devices. Lateral lines fitted with emitters are placed on the soil surface along crop rows. Pressure is low so the water emerges as drops rather than as spray. Emitters control the discharge of water from the lateral lines to the plants, with one line used to irrigate one or two rows of crops, depending upon their spacing. Emitters are placed off the soil surface to prevent clogging and are calibrated to release between 2 to 16 liters per hour. The ends of the lateral lines are periodically flushed to discharge particulates. Drip irrigation emitters are "pressure compensating", meaning that they can discharge water at a very uniform rate under varying water conditions. This trait allows for more constant flow under fluctuating input pressure and different slopes. Some drip irrigation emitters are built with a self-flushing mechanism reducing the risk of clogging, others are flushed by opening the end of each line.

Availability and Commercial Opportunity. One acre (0.4 ha) of land may be placed into surface drip irrigation for about US $1120 with costs as follows: drip lines (US $770), pump and filter ($166), poly main and sub-mains ($100), and valves and fittings ($88). Drip irrigation is closely associated with greenhouse horticulture and higher value crops. A quick internet search of drip irrigation suppliers in Kenya revealed over 20 suppliers of drip irrigation materials, including many suppliers outside of Nairobi. Some suppliers provide complete "kits" for 1/8 and 1/4 acre. In many cases, suppliers will assist in the design of these systems as they sell the materials required for it. Another search revealed 14 suppliers in Lagos, Nigeria but fewer suppliers away from the city. Opportunity exists to develop agribusinesses around the design of drip irrigation systems and the sales and installation of its materials, but several African countries still do not have ready access to this technology.

Technology 6. Rain Guns for Low-Cost Irrigation

Background. A rain gun is an irrigation device that supports high water flows and an extended radius of "water throw" through its sprinkler. They allow relatively few stations to cover large areas of field, and at the same time are portable, allowing a gun and its stand to be moved to different field locations according to needs and schedules. These guns require high water pressure and flow and can project water for up to 60 m in distance that covers a circular area of 1.1 ha. This coverage allows these systems to be installed quickly and cost-effectively assuming the conditions for their reliable operation are met. At the same time, adjustable jets allow control of the throw, droplet size and impact to suit the irrigation needs of more delicate crops.

Water gun used for irrigation large areas of field from a single position

Advantages and Disadvantages. Rain guns offer major advantages to farmers seeking to place substantial areas of land into irrigation is a simple way but also require that precise conditions in terms of water quality, flow and pressure be met. Each water gun is mounted upon a stand that raises it off the ground so that its throw does not disturb adjacent plants. The base of the stand is connected to a water source, in most cases a flexible hose like that used by firefighters. This allows the rain gun and stand to be moved to different stations so that only one gun covers large areas of field (e.g., 4 to 6 ha) depending upon water requirements and irrigation schedule. The coverage is adjustable in terms of distance, droplet size and completeness of circular angle, with 360^{o} projection most common. Claims exist that the force of rain gun water is sufficient to disrupt the activities of some pests. At the same time there are disadvantages, even beyond the exacting requirement for water. The rain gun operates from a central pivot position that is not suited to smaller or irregularly shaped fields. Because it operates at such high pressure, the rain gun must be handled with caution and its parts must be well maintained and regularly inspected to ensure against wear. Each rain gun requires substantial investment and is usually serviced by a single high pressure – high volume water pump that must also be purchased and maintained. Strong winds adversely affect water coverage. Rain guns allow farmers that have relied upon rainfed production of field crops in the past to adopt irrigation as a practice, reducing risks of climate change

Options and Specifications. Rain gun technology is designed for a variety of uses and applications where relatively high flows and extended radius of the water throw are required. These sprinklers operate at pressures of 2.5 to 7.5 kg/cm^2 and flows of 5 to 30 liters per second. Below these thresholds, the gun does not function in a uniform and reliable manner. The nozzle diameter is in many cases interchangeable, 10 - 30 mm, resulting in wetting radius of 25 to 60 meters. At highest flow rates, one position can deliver sufficient water for crop irrigation in as little as 2 or 3 hours, allowing for repositioning several times a day.

A high-pressure, high-volume rain gun in operation, projecting irrigation water up to 60 m from a single field position

Availability and Commercial Opportunity. Rain gun and their accompanying materials are not widely available in many African countries, but it is important that they become so. A quick search in Kenya discovered over 10 suppliers in Kenya, including those away from Nairobi, as well as importers from China and India. They were readily available in Uganda as well, although some only throw water 30 m. Similar findings were obtained for Nigeria although there was not a clear distinction between rain guns and more conventional sprinkler apparatus. The advertisements in Zambia were mostly posted by importers rather than local suppliers but electronic discussion on rain gun technology is ongoing. Many other countries lack suppliers, and this provides commercial opportunity. A complete rain gun irrigation system was recently purchased in Nairobi for US $669 after comparative shopping. The components and costs were rain gun head (US $140), tripod stand ($90), 90 m hose ($110), 2" high pressure 7.5 HP water pump ($290) and 6 m suction hose ($39). These systems are affordable to farmers conducting small-scale commercial enterprise and must become more available across Africa!

The stand of a rain gun; note that water enters from the base through a threaded fitting and is delivered to the rain gun mounted at its top

Technology 7. Mechanized Threshers for Efficient Processing

Background. Threshers are power equipment that separate crop residues from seed and grain in a time-efficient manner. These machines are powered by small petrol engines and consist of a feed chute that leads to a threshing chamber where crop residues are separated from seeds in a rotating drum, and then a blower removes lighter residues. Operators put in dried harvest materials through a feed chute, pushing materials into an internal spinning drum where seeds are physically separated from crop residues and then fall through a screen. Whole shoots may be passed through the machine rather than pods and heads alone. Remaining crop residues are then expelled through an exit chute. These chopped materials have further use as organic resources. The seed is passed across a blower that removes finer materials (e.g., dust) that winnows (cleans) the seed, passing through a collection chute that allows the seed to be bagged. Different types of crops may be processed based upon the screen mesh. Threshers are available to process crops such as maize, rice, common bean, wheat, sorghum, millet, sunflower, and pigeon pea.

Multi-crop thresher with in-built engine

Advantages. Typically, women are assigned the task of manually threshing crops by hitting piled harvest with sticks until the grain falls loose, a task that requires about one hour of work to recover 25 kg of seed. Small-scale mechanical threshers can process seeds and grain many times more rapidly than traditional threshing and winnowing operations. Mechanized threshing is very labor efficient, allowing for the processing of between 150 to 500 kg of saleable product per hour, depending upon the crop and machine. The smaller the seed, the more rapid the processing time. Not only is processing more rapid but also more thorough because the in-built blower cleans grain more completely than traditional winnowing. Mechanized threshers cause less breakage to grain and seed than manual beating which gives farmers a quality and market price advantage. Mechanized threshers separate and clean grain and seed in one single operation, making produce ready for sales on local markets or trading without need of further processing.

Power thresher processing sorghum grain

Options and Specifications. Different types of power threshers are available which are distinguished according to the type of crops they process (e.g., single crop or multiple crops), according to their mode of operation (e.g., batch drum or axial flow), and the type of threshing cylinder (e.g., syndicator, beater, spike tooth and rasp bar). The smallest threshers weigh as little as 100 kg and may be mounted on motorcycles for on-farm use. Portable threshers are positioned next to piles of harvest on a level surface. Larger machines may be transported by small trucks and established within communities for collective use by farmer groups. Threshers have a modular design, and their basic components include a feeding chute, threshing cylinder, aspirator blower, chaff outlet, straw outlet, hopper, and cam for oscillating sieves, oscillating sieves, transport wheel, frame, and main pulley. Small engines (5 to 8 HP) that consume only 1 to 2 liters of fuel per hour typically operate these threshers. These threshers are often mounted on wheels and have handles that permit their movement. A tarp is set below the collection shoot to keep the seeds clean and to facilitate bagging. Residues must be periodically raked away as they are ejected from the exit chute. It is extremely important that operators of these machines must be trained in the maintenance, minor repair, and safe use of this equipment and that they be operated without distraction (see section "Safety First!").

Availability and Commercial Opportunity. Some threshers are produced in Africa, and a large number are available for import. A quick internet search gives 110 thresher models offered by suppliers from India and 52 from China, although some were intended for use on only one crop or for small grains only. There is scope for commercial provision of threshing services that make better quality grain available to households sooner after harvest. This post-harvest service may be provided by independent business interests or as a means of assuring grain quality to produce buyers. Marketing threshers is a different matter and involves either distributing fabricated equipment or importing it. Large discounts are available to those importing equipment in larger quantities. Multi-crop thresher machines are sold by suppliers in Tanzania and Kenya at US $780. It allows operators to earn income by reducing drudgery on farms and requires less than 80 hours of paid operation to break even. Operators charge US $10 per hour and can process up to 225 kg of maize or 280 kg of beans per hour, relieving households of 40 hours of drudgery per acre of harvest. Assuming the lowest of wages, this results in savings of US $35 per day and reduces the cost of threshing by more than 50% compared to paid manual threshing. One business owning several thresher machines can employ 20 people as a profitable business. Huge potential exists to offer additional threshing services across Africa!

Small threshers are portable, permitting service provision at the farm level

Technology 8. Residue Cutters and Choppers for Livestock Feed

Forage chopper with in-built engine

Background. Residues and stover from crops offer an important source of livestock feed but owing to their bulk their preparation using manual labor is extremely time consuming. When animals are herded over croplands after harvest, only 20-30% of stover is eaten since they prefer the sweeter parts that are easier to digest. Access to quality feed is the most important factor in successful livestock rearing. Many farmers feed whole stover to their animals which slows down their digestion and causes sub-optimal growth. Motorized residue processing is ideal for mixed crop-livestock farming, particularly where underutilized crop residues are plentiful, and costs of animal feed are prohibitively high. Small-scale motorized cutters facilitate collection of stover from the field, allowing residue recovery from several hectares in a day. Use of motorized choppers and crushers make it possible to provide suitable feed and mulch for soil cover while saving time and effort. Depending on the chopper model, throughput capacities range from 1 to 1.5 ton of stover per hour.

Advantages. It takes a lot of time from farmers to manually collect crop residues from the field and chop these into small pieces by hand so it can be consumed by cattle. The manual process limits the amount of stem residues that farmers utilize for livestock. Motorized cutters and choppers address this constraint and improve organic resource management within the farm. The machines are self-powered, easy to operate, low-cost, easily transported between fields, and allow large amounts of crop residues to be processed from fields by only two workers. These machines are suitable for a wide range of fresh and dried materials available throughout the year Mechanized residue processing benefits storage and preservation of feed products by making it possible to compact the material in bags that can tightly packed instead of loosely piling whole stover into a shed. Packing enhances flavor and

Use of motorized stover cutter (left) and mobile chopper (right)

nutritive value as well. Increased availability of chopped and shredded residues from crops is fundamental to local production of well-balanced feed rations. Chopped and crushed stover from cereal and legume crops is also suited to produce silage. Through mechanized residue processing, farmers can earn additional income, rear larger numbers of animals, increase milk and meat yield, and avoid feed shortages during dry seasons or prolonged drought. The technology serves both animal and crop production since residues fed to livestock produce manure which in turn improves soil fertility when returned to the field.

Options and Specifications. Motorized chopper machines can be used for either fresh and dry plant materials from a wide range of cereal crops like maize, sorghum, and millet, as well as legumes such as soybean, groundnut, and cowpea. Chopping works best for green stover before fibers harden, while crushing is mostly done after residues have dried. Chopper machines have four main parts; a pair of horizontal rollers that moves stover forward, a hexagonal shear cutter with knifes, a hammer for crushing the chopped stover, and a 7 to 13 horsepower engine running on petrol or diesel. Choppers and hammers work at the same rate as the roller to ensure uniform sized feed material. Material is further ground through the beating action of the hammers until it passes through holes in an adjustable screen. Crushed material is pushed forward by the motion inside the chamber. Residue processing machines are easily transported between fields and farms using a donkey cart of motorbike. Most residue choppers are fitted with wheels.

Availability and Commercial Opportunity. Motorized cutters and mobile choppers are commercially available in many mixed crop-livestock farming communities across Sub-Saharan Africa. Demand for the technology is rapidly growing thanks to its many advantages and dissemination by national agricultural development agencies. Motorized cutters that can handle all types of cereals cost about US $1,000 to $1,500 on international markets. Local sales prices for new stover choppers with in-built engine ranges from $1,250 to $1,700 depending on the size, the manufacturer, the country of origin. Imported models are usually more expensive than locally fabricated ones. This small-scale equipment may be offered as a package to individual farmers, their associations, other service providers or feed producers. Processing stover from cereal and legume residues offers an attractive business opportunity since added value is created and market demand exists. Return on investment depends on the cost of whole stover, labor, fuel and maintenance, cost conditions that vary between locations and times of year. Machines provided to farmer associations led the production and sales of more than 100 tons of stover worth US $22,000 in less than six months. On animal feed markets in many African drylands, one ton of crushed stover sells for US $330 to $500 depending on the quality and time of year. Starting a forage chopping business may indeed be a timely investment!

Cured silage from chopped crop residue

Safety First!

It is extremely important that the small-scale machines featured in this catalogue be handled in a safe and responsible manner, and in accordance with manufacturer's instructions. Some guidance in these safe operations follows.

Despite the excitement, operators must have sufficient strength to handle power equipment

Hand tractors. The danger from hand tractors (Technology 1) is damaging feet and lower legs by the rotating tines and operators must remember to wear protective footwear and keep feet well back from power train. Another danger exists when roots and rocks bind the tines, and operators must turn off the power before disengaging them. Operating hand tractors on steep slopes is inherently dangerous. Even when turned off, the times may recoil so tools, not hands, should be used when cleaning these machines after each use. Children should not operate hand tractors despite their enthusiasm to do so!

Mechanized weeding operations. Mechanized weeders pose the same dangers to users as hand tractors, particularly the mini-cultivators (see Technology 2). Because they are lighter in weight, the tendency is to swing them around quickly to avoid contact with crops. Again, tines may become bound by roots, rocks and clods, and operators must turn off the equipment and rely upon tools before disengaging them because the tines may recoil once freed. Particular care must be taken when using the circular rotating blades of backpack weeders to trim woody vegetation because they tend to be swung in a sidewise motion away from the ground and they may recoil causing loss of control of this devise, even posing a danger to others.

Power sprayers. Operators must always be aware that power sprayers (Technology 3) can discharge large amounts of harmful substances and wear protective gear. This gear includes respirators, eye shields, gloves, water resistant clothing and boots. Spraying and wash up must be performed in an environmentally responsible manner and according to product specifications. Many locations have specific regulations on the safe disposal of pesticides and their wash water and special care must be taken not to contaminate waters and farm animals.

Operators of sprayers must always wear protective gear (right, never left)

Land augers. The greatest danger from augers (Technology 4) is injuring the operator's feet or legs with the rotating screw. When encountering rock or roots, the device may recoil out of control and operators must be solidly positioned against this. If the bit jams, one must turn

off the auger before dislodging it and always keep hands away from rotating screws. Operators must always wear protective boots and resist the temptation of rushing from one hole to the next with the machine engaged.

Rain guns. The safety precautions taken during installation, use and dismantling of a rain gun (Technology 6) include ensuring that the gun is securely fixed to its stand, avoiding the fast reverse rotation of the gun as it operates, and ensuring that "quick couplings do not slip and discharge uncontrolled. Adjustments to the gun's diffuser screw should not be made as it operates and once in operation, one should remain at least one meter away.

Multi-threshers. Power threshers greatly reduce labor requirements, but their operations are inherently dangerous unless the machinery is operated as intended (Technology 7). Threshers require that crops be fed manually through a feeding chute into a spike-tooth cylinder and chaff-cutter that can seriously injure hands. Human factors such as inattentiveness, overwork, wearing of loose clothing, failure to remove wristwatches and bracelets, and use of intoxicants greatly increase this risk. Threshing accidents can be minimized through the following measures: 1) Threshers must be fitted with a safe feeding chute at least 90 cm in length with half of that covered, 2) Only skilled and trained workers should operate a thresher who avoid talking and unnecessary distractions while performing their duties, 3) Extra care must be taken when feeding crops lacking stalks into the thresher as this requires closer proximity of hands to moving parts of the machine, 4) Ensure proper lighting if the machine is to be operated at night and the area surroundings the thresher must be kept free of obstructions, and 5) Do not smoke or light a fire near the threshing yard as the dust and residues from the thresher are extremely flammable. The thresher workstation should include a first aid kit.

Safe operation of a crop thresher on Ethiopia (photo from the Sasakawa Africa Association)

Forage choppers. Safety must be practiced when using forage choppers (Technology 8) because of their several moving parts resulting in cutting action. Operators are expected to push fresh or dried plant materials into a chute so that it is cut into various sizes, and then collect and remove chopped material as it accumulates. Equipment must be carefully inspected, and users must understand the importance of protective shields as they operate the machinery. Care must be taken not to feed the chopper woody material or rocks that can damage the blades. Forage crops are often grown on rough and steep land, and the choppers are portable, but operators must not set the chopper on land that is not entirely stable. Otherwise, the same safety precautions apply to both threshers and forage choppers.

This section serves only to highlight the extreme importance of safety in the operations of small-scale farming equipment as these machines are intended to reduce human drudgery and not cause injury. Most accidents result when operators become rushed or overconfident.

Youth-led Mechanization

The aversion to careers in agriculture among young people results from the perception of necessary drudgery and poor returns to effort. Wider reliance upon small-scale farming equipment serves to counteract this misconception. One important mechanism to promote this equipment is through the activities of youth groups, allowing for skills development in the use, maintenance, and safe handling of these machines. This route is particularly relevant when youth undertake agribusiness incubation leading to their development of innovative agribusinesses and modernization of their home farms, affirming that they are no longer bound to practice agriculture in ways overly reliant upon manual operations. In this way, mindset change results from exposure and hands-on learning, allowing youth to embrace agriculture as a mechanized and profitable pursuit, and to find commercial opportunity in advancing mechanization as a growing trend across the small-scale farming sector. Agricultural mechanization and modernization equipment allow young producers to optimize their time and reduce production costs. Furthermore, larger farming communities demand for mechanization services from youth create opportunity for further income generating option. Several examples of this trend follow.

In Zambia, the use of a hand-held tractor for land preparation and furrow making is less costly and more labor efficient, increasing crop yield and profit for young rural entrepreneurs. A variety of attachments is available to not only rotovate the soil but to also establish raised beds, irrigation furrows and erosion control structures. Similar youth enterprises in Uganda and Kenya also provide mechanized weeding services to farmers.

Land preparation conducted by youth as a service to the farming community

Youth are actively engaged in the control of Fall Armyworm and the Yellow Desert Locust, two insect invasions with dire consequences to African farmers. Reliance upon a power sprayer and alliance with agrodealers networks increased the efficiency of this service provision. At the same time, youth were well positioned to access control information via electronic media and to comply with health and safety requirements. Farmers discovering widespread invasion of maize fields were particularly motivated to see contractors provide rapid services that saved their crop. Reliance upon power sprayers allowed operators to treat fields five times more rapidly than others using pump action backpack sprayers, and to offer better coverage of leave undersides and inside whorls at the same time. Youth-led Rapid Response units operating from agrodealer shops developed toolkits consisting of a customized cargo tuk-tuk, power sprayers, safety equipment, commercially recommended pesticides, farmer information materials and communication tools. One group in West Kenya serviced 227 clients, treating an average of 0.20 ha per client at a cost of US $5.68 each, equivalent to only US $28 per ha. Subscription to this service resulted in a return to investment of 4.1:1 in terms of rescued maize. Similarly, youth offering spraying services to farmers earned approximately US $2000 a month in Uganda.

A team of youth in Uganda founded a business called “Mr. Clean” that weeds and plows land for a fee. Over time, their services included contracts with the Uganda National Roads Authority to control unwanted vegetation along roadsides. Now they offer assistance to other youth-led startups unable to afford their own machines.

A pond aerator installed by an Agripreneur youth group

Youth have capacity to operate at the cutting edge of technology. Some developed expertise in the installation of pond aerators enhancing the levels of oxygen in fishponds and greatly improving water quality and fish health. Others developed expertise in the operations of drones used for small-scale aerial spraying of crops. Youth in Kenya adapted land augers to quickly prepare water-harvesting features for dryland agriculture, mechanizing the establishment of a climate-smart cropping practice and reducing its labor requirement four-fold.

Youth preparing a sprayer drone for flight

These opportunities have an institutional dimension as well. The ENABLE-TAAT Compact works in partnership with the Government of Benin to introduce small-scale mechanized farming to the country’s youth. The greatest opportunity, however, resides with the private sector. Once skills in the management of small-scale farming equipment is obtained, it is possible to grow an importation and retail business around this expertise. The price difference between these different equipment sold in quantity and the local sales prices in Africa are quite large, allowing for reasonable profits to be made from modest turnover of stock. These machines once sold serve as the focus for additional youth-led businesses that offer contract services to farmers, reducing the drudgery associated with agriculture in an incrementally improved manner.

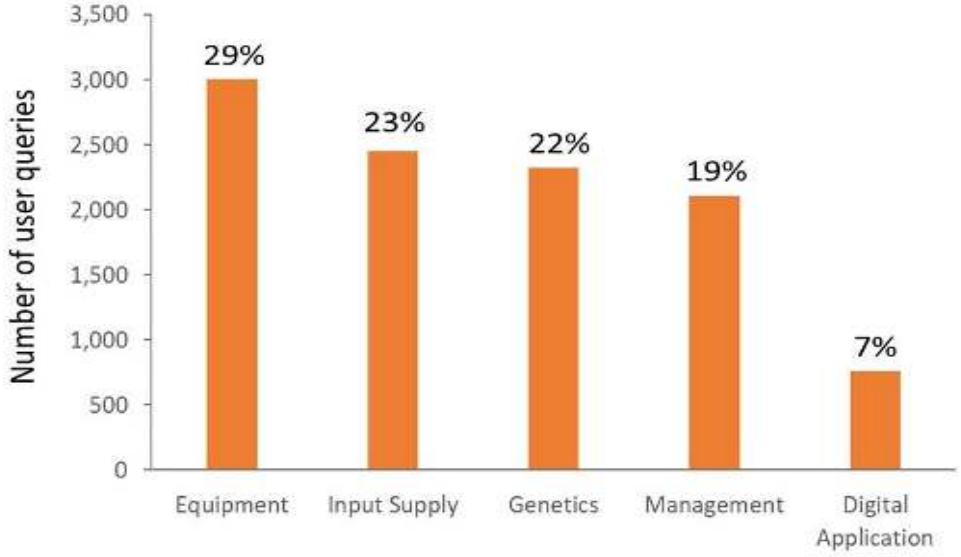
Make TAAT Your Technology Broker of Choice

TAAT offers its services toward the advancement of modernized agriculture. It brokers a wide range of needed technologies and bundles them through a process of co-design into winning solutions. It recognizes that modernized agriculture must serve as the main engine for economic growth in Africa and operates accordingly. Change is intended to achieve not only food and nutritional security but also to meet obligations under climate agreements allowing collaborative efforts to better combine global, national, and community-level interests. TAAT operates from this unique perspective to mobilize innovative solutions through better partnering that includes honest technology brokerage and effective, scalable skills development through five key mechanisms.

- ☑ **Unique understanding.** Expertise is offered in the areas of site characterization and problem identification.
- ☑ **Innovative solutions.** Leadership is provided in technology brokerage and solution bundling based upon a dynamic portfolio of candidate technologies.
- ☑ **Better partnering.** Assistance is offered in the better co-design and management of projects prompting agricultural transformation.
- ☑ **Honest brokerage.** A robust capacity for impact assessment and constructive learning is achieved through standardized monitoring and evaluation.

Conclusions

This catalogue describes the role of small-scale farm machines within Africa's agricultural transformation and several of that equipment that are most important to that process. Small-scale farming is widely associated with lives of poverty resulting from subsistence agriculture and drudgerous manual labor. This perception must be changed if commercialized agriculture is to drive rural economic development, particularly among talented youth that will provide farming's future generations. Too often, these youth are seeking ways to escape



User queries directed to the ProPAS website offering information on agricultural technologies

agriculture as a career path rather than committing their lives to exciting new enterprise opportunities. Mechanization is key to this commitment, both in terms of greatly reducing manual labor associated with core farm tasks, but also in designing livelihoods around the innovative services that support mechanization. The growing importance placed upon mechanization by the agricultural community is reinforced by recent findings of the ProPAS internet site where more queries were directed toward mechanization technologies than any other category.

Contract services offering use of these equipment are particularly important. Reliance upon hand tillage often results in portions of fields remaining idle because there was insufficient time and labor to prepare them for planting. Cultivated farmer fields often become weedy for the same reason. Insect invasions go unchecked because their swarms overwhelm available control options. Droughts destroy crops in places where irrigation water is only slightly out of reach. The market value of grains is reduced because manual threshing results in excessive damage to processed harvests. All of these constrains are readily met with technologies presented in this catalogue!

The advantages of power tillers, weeders and sprayers are obvious to anyone who has undertaken their laborious manual alternative, but challenges must be met to make this machinery available and to keep them functioning. Equipment suppliers must extend their sales further into rural areas, and agrodealers must be willing to invest in and market this equipment. Farmers must join together to purchase and share these machines. Extension agents must promote mechanization and mechanics must develop the skill sets needed to maintain and repair the equipment or else it risks falling into disuse. Development specialists must recognize the extreme importance of small-scale mechanization to Africa's agricultural future and accommodate this need within the formulation of rural development projects through the design of public-private partnerships. It seems the smaller the equipment, the more relevant it becomes to poorer farmers, and incentives must be offered to these labor-saving machines within their reach, and to create jobs for their families as service providers of these equipment into the future.

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Technologies for African Agricultural Transformation (TAAT) and its Clearinghouse Office

The development objective of TAAT is to rapidly expand access of smallholder farmers to high yielding agricultural technologies that improve their food production, assure food security, and raise rural incomes. This goal is achieved by delivering regional public goods for rapidly scaling up agricultural technologies across similar agro-ecological zones. This result is achieved through three principal mechanisms; 1) creating an enabling environment for technology adoption by farmers, 2) facilitating effective delivery of these technologies to farmers through a structured Regional Technology Delivery Infrastructure and 3) raising agricultural production and productivity through strategic interventions that include improved crop varieties and animal breeds, accompanying good management practices and vigorous farmer outreach campaigns at the Regional Member Country level. The important roles of sound policies, empowering women and youth, strengthening extension systems and engaging with the private sector is implicit within this strategy. The Clearinghouse is the body within TAAT that decides which technologies should be disseminated. Moreover, it is tasked with the responsibility to guide the deployment of proven agricultural technologies to scale in a commercially sustainable fashion through the establishment of partnerships that provide access to expertise required to design, implement, and monitor the progress of technology dissemination campaigns. In this way, the Clearinghouse is essentially an agricultural transformation incubation platform, aimed at facilitating partnerships and strengthening national agricultural development programs to reach millions of farmers with appropriate agricultural technologies.

Back cover photographic credit: Correct (left) and unsafe (right) personal protection while spraying pesticides.

TAAT

Technologies for African Agricultural Transformation

Small-scale Farm Mechanization Catalogue

In collaboration with:

AATF Prosperity through Technology

AfricaRice Rice science at the service of Africa

Alliance Bioversity International CIAT

ICARDA

CIP International Potato Center

FARA Forum for Agricultural Research in Africa

ICRISAT International Crops Research Institute for the Semi-Arid Tropics

IFDC Developing Agriculture from the Ground Up

ILRI International Livestock Research Institute

IWMI International Water Management Institute

WorldFish