A round tour of mechanisation

What is mechanisation like in different world regions? Which challenges do farmers face in Latin America, sub-Saharan Africa and South Asia? Jelle Van Loon, Frédéric Baudron and Timothy Krupnik, working for the Global Conservation Programme, headed by Bruno Gérard, at the International Maize and Wheat Improvement Center (CIMMYT), give accounts of their experiences.

Jelle Van Loon
is based in CIMMYT/Mexico. He leads the machinery and mechanisation unit focusing on agro-technical analysis of farm machinery and tools. It involves the production of 'easy to follow' machinery construction guides and the design of modular, multifunctional equipment adapted to various farmer's needs.

Frédéric Baudron
is working for CIMMYT in Eastern and Southern Africa, based in Ethiopia. He got into mechanisation R&D from a farming system angle, realising that farm power was a major limiting factor to the productivity of many farms in Africa, as much as good seeds and fertilisers.

Timothy Krupnik
leads CIMMYT's research on appropriate mechanisation in Bangladesh and contributes to mechanisation research and scaling work in India and Nepal.

Rural 21: *Jelle, Frédéric and Timothy, you work in very different regions throughout the world. What is the level of agricultural mechanisation like in these regions, and what impact does it have on day-to-day farm work?*

Jelle Van Loon: Mechanisation levels vary a lot within Mexican borders. In rough terms, the northern states are dominated by big farms with highly advanced machinery and irrigation systems; moving southwards, this gradually changes and turns into subsistence farming with traditional hand tools in the most southern states. In between, there is a mosaic of medium-sized farmers using small four-wheel tractors and smallholder farmers using animal-drawn tools or working with hand planters. Large farmers look for high-precision tools for large fields, while medium and smallholder farmers are stuck between the choice of investing in machines or hiring services. Service providers to medium and smallholder farmers usually lack modern equipment, and so those farmers have limited access to appropriate services. Small tools are in high demand in these farmer groups and include manual equipment, animal drawn-implements and small motorised machinery, including two-wheel tractors. Subsistence farmers rely greatly on non-motorised tools, and here attention should be on functional design and ergonomics, but most importantly on durable solutions.

Frédéric Baudron: In the past decades, both the number of tractors and the number of draught animals have been stagnating – or even declining – in sub-Saharan Africa (SSA). This means that SSA smallholder agriculture is increasingly relying on labour – that is human muscle power. We see labour shortage becoming an issue. This stems from rural-urban migration, an ageing rural population, off-farm income opportunities and the consequences of HIV/AIDS. Today, more than 50 per cent of the cropland in Eastern and Southern Africa is cultivated by hand. Tractors are only used on 20 to 25 per cent of the cropland, and on less than 10 per cent in Western and Central Africa. The history of mechanisation in Africa has been dominated by 'tractorisation' – that is the promotion of tractors with four wheels and two axles – through government-run hiring schemes, since the 1950s or 1960s. Most of these schemes collapsed in the 1990s. 'Appropriate mechanisation' was an interesting alternative movement during the 1970s and 1980s. Small machines are probably more appropriate to the small and fragmented fields of most African farmers and more affordable than large ones. The main problem was that these machines were developed without understanding the demand – no involvement of farmers during the R&D – and with no consideration of their commercialisation – i.e. no involvement of the private sector during the R&D.

Timothy Krupnik: Much of South Asia is already highly mechanised, with over 500,000 two-wheel tractors in Bangladesh alone (although they are used primarily for tillage), 1.6 million irrigation pumps, and over 250,000 threshers. This makes a great platform to build on, as farmers are quite familiar with mechanisation. We focus on more efficient and effective use of machines, especially with respect to agronomic aims like introducing line sowing by seeders that can be attached to two-wheel tractors, or to conservation agriculture practices. In South Asia, we are witnessing a transfor-

mational shift in rural economies where more and more farm family members are migrating to cities or abroad to look for work. In Bangladesh, for example, labourers can typically make more money pulling rickshaws or by gaining employment in the garment industry in the capital than they can by working on farms. Consequently, labour scarcity is increasingly common, despite this country's high population density, resulting in increasing levels of mechanisation. In Bangladesh, much of the machinery that has been adopted by farmers falls into the category of 'appropriate' in terms of being designed for the small-scale, highly fragmented nature of farmers' fields, with mechanisation expanding since the 1990s, owing to policies facilitating the import of inexpensive 8–16 hp engines for two-wheel tractors and associated equipment from China.

In many SSA landscapes, most of the farm power is still provided by men, women, and children. Do you think mechanisation through animal traction is a necessary step to 'engine' mechanisation?

FB: Looking at mechanisation as a 'ladder', moving from manual agriculture to animal traction, then to the use of small machines and ultimately, to the use of a large four-wheel tractor is inappropriate. Patterns of mechanisation have been very diverse in developing countries, and 'big tractors on big fields' is not the solution everywhere. In developing countries, a source of power is rarely completely displaced by another, and as such, manual labour and animal traction is frequently found in countries where motorised machines became common. We should aim at mechanising operations that are critical for productivity gain (for example, timely planting) and operations that are currently characterised by high drudgery (for example, threshing), while recognising that other operations will continue to be manually performed by labourers and draft animals.

TK: I am in general agreement with Frederic's points, although one also needs to note that for engine-based mechanisation to really take off at scale, a diverse set of supplementary markets and services are needed. For example, machines and spare parts first need to be made available on a reliable commercial scale, mechanics must be easily found, and most importantly, a reliable and regular fuel supply is required, although all of this may be underdeveloped in many areas. There are still many parts of Africa – particularly in the Sahel – where one may need to walk two or three hours simply to find a market selling fuel to power machinery. Where this is the case, as an intermediary step, it makes sense to focus on improving farm equipment used in combination with animal traction, as part of a dual-track strategy.

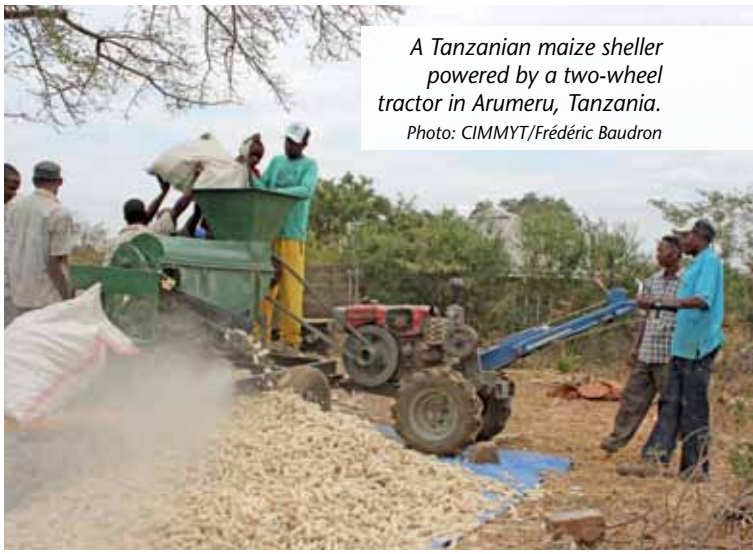
How can we explain the different levels of mechanisation between sub-Saharan Africa, South Asia and Latin America? Any cross-continental learning of interest?

TK: Even within the same region, for example in Latin America, you can have all the 'levels' of mechanisation, depending on the environment, crop, and market systems within each. What is perhaps more useful to think about is farmers' level of access to machinery, and the level at which farm equipment markets have developed. In this sense, mechanisation has certainly taken off more dramatically in South Asia and in Latin America, compared to sub-Saharan Africa. Our research in South Asia shows that mechanisation tends to take off particularly where the underlying socioeconomic and infrastructural conditions are right. We've found that there is more adoption of machines, and consequent service provision to farmers, where rural credit is more available, where electrification is more prevalent, and where road networks are denser, all of which indicate relatively well-functioning markets.

If the level of mechanisation adoption is low in many systems, what do you think the main constraints are to wider adoption?

FB: We need to identify the tasks for which there is a demand for mechanisation, including willingness to pay for a machine or a service. We also need to identify or manufacture suitable machines, and adapt them if necessary. Many two-wheel tractors are sold in Africa with a rotary hoe and a plough, both being pretty useless in rainfed systems. 2WTs can produce enough traction to plough wet paddy fields, but not always the dry soils in rainfed conditions. The demand also needs to be created. Most SSA farmers are simply not aware of the range of mechanisation options that could be available. Importers and manufacturers are present in most countries, but they don't invest in promotion.

TK: We face this problem with some of the improved, resource-conserving equipment that we work with in South Asia, and as a result we have been aggressive in getting the word out about the options available to farmers. Compared to seed or basic changes in agronomic management, which require less investment, purchasing machinery – especially those using engines – is not something risk-averse farmers will take lightly. So, by facilitating arrangements with banks and specific NGOs that can offer lower-risk loans tied to technical support for farmers, and by assuring they are running profitable machinery service provision businesses, some constraints are reduced.



A Tanzanian maize sheller powered by a two-wheel tractor in Arumeru, Tanzania.
Photo: CIMMYT/Frédéric Baudron

You all work for a research programme at CIMMYT that is focusing on Conservation Agriculture. How do mechanisation and CA get along?

FB: This is a completely synergistic relationship: CA makes small mechanisation possible, while small mechanisation alleviates one of the major barriers to the adoption of CA. Why do we need big tractors? A lot of horsepower is mostly needed for ploughing. 2WT tractors are not powerful enough to plough most soils in rainfed condition. But they are perfect to pull simple tines or discs through the topsoil, without inverting it. Therefore, removing tillage, a fundamental principle of CA, makes the use of 2WT possible. On the other hand, the lack of appropriate implements to seed at the right depth through an organic mulch and with minimum soil disturbance is a major constraint faced by smallholders on adopting CA. Delivering mechanised CA to smallholders is therefore a way to stimulate CA adoption. It could also be argued that replacing draught animals by 2WTs would release a substantial amount of biomass – currently fed to draught animals – for mulching.

A service provider in Barisal, Bangladesh, prepares a farmer's field with a bed planter that was the result of research collaboration by CIMMYT, the Bangladesh Agricultural research Institute, and Cornell University.
Photo: CIMMYT/Ranak Martin

TK: Successful implementation of CA requires the right software, in terms of farmers' knowledge on how to move from tillage to no-tillage, use of residues as mulch, and profitable crop rotations. But it also requires the right hardware, in terms of the right equipment adapted to these practices, while being appropriate for the scale of farmers' fields, and for the size of their wallets. Most CA equipment has been developed for large four-wheel tractors in developed nations, where farmers have very, very large fields. While some of the components of these machines will be useful in the areas we work in, machinery needs to be adapted to suit the conditions that smallholders face.

Many large companies overlook smallholders, and focus on implements for wealthier farmers and larger fields. Our work is thus aimed at re-designing and adapting equipment to be more appropriate for lower horsepower tractors, and to the diverse soil conditions and crops encountered in the tropics, while making sure that the machines are produced at a price point that agrees with service providers.

JVL: The principles of CA as a resource conserving practice focus on more efficient use of farm input, including seed, fertiliser, fuel and water. Re-designing and refurbishing machinery – incorporating precise and economical seed-fertiliser meters in small-scale, low fuel consuming equipment that can perform a variety of tasks through a modular setup, which minimises the need for investing in a large machinery package and the complexity of repairs, and this while reducing soil disturbance and soil compaction through controlled traffic, etc. – to work under these conditions goes parallel with the implementation of these agronomic principles. As such, adequate farming techniques can only be promoted if appropriate equipment is available.

You are cooperating with numerous partners. What could still improve in this respect?

FB: We work with importers and manufacturers, mechanisation testing centres and universities, training centres and extension services, NGOs and policy-makers. This cooperation is working out very well. What is missing in most situations is a broker, an intermediary who facilitates linkages between the private sector and smallholder farmers. A broker is not needed where agricultural markets are well-developed and demand is high. In such a situation, the private sector is likely to emerge as the initial and main driver of the chain. Where agricultural markets are weak, demand for machinery and their services is low (because of lack of awareness), and farmers (the clientele) are vulnerable to shocks and stresses, so that a broker is needed to facilitate linkages. Once demand can be assured, intermediaries would be expected to exit, allowing the private sector to step in and scale-out the technologies. In the absence of such a broker, this role is being assumed de facto by projects, which often have neither the resources nor the mandate for this job.

Mechanisation is knowledge-intensive, so what are the knowledge products you are producing, and for whom?

FB: In Africa, promotional materials targeting farmers – our end-users – to create demand is essential. These are mainly posters and leaflets. We also target businesses, crucial 'first users', NGOs, and extension services through factsheets, videos, newsletters and a regularly updated website.

TK: To date, we have developed five 20–30 minute training videos that explain the benefits of the direct sowing, irrigation, and harvesting equipment in South Asia. Videos are then shown in village gatherings to raise awareness, with over 120,000 people having seen the videos since 2013, and

audiences of several million when they are aired on national TV. We are also in the process of developing the first comprehensive compendium of participatory, experiential learning-oriented training modules on appropriate agricultural machinery, for seed drills, axial flow pumps, and harvesters, expected to be completed sometime in 2016. We have also developed materials – open-source technical designs and blueprints – beneficial to manufacturers.

Are there still 'technical challenges' regarding mechanisation?

JVL: One challenge revolves around the practical design of a machine or tool, and this all falls back to the following main aspects: 1) a tool that is versatile enough to work in very diverse soil and farm conditions, 2) a tool that is easy-to-operate to minimise training needs and has an ergonomic design (light weight, user-adjustable configurations) to minimise drudgery, and 3) a tool that is easily repaired and whose parts are readily manufactured or available. A second challenge is the local production capability and manufacturing quality. Equipment with many intricate parts is difficult to reproduce or duplicate. Protocols to ensure a minimum level of manufacturing standard should be implemented.

Finally, challenges definitely arise when thinking about the propagation of functional machinery packages. How can an environment be stimulated into consuming (as in sell, buy, use, and reuse) a different or adapted tool set different from the generally accepted set? The sustained creation of demand for untraditional tools is needed to stimulate the market players, and to achieve this, suitable business models need to be developed.

Last but not least, from some documents you have shared, your mechanisation research for development appears to have a strong gender lens. Can you develop?

FB: Women supply most of the labour in African smallholder agriculture, and are often the ones performing the most labour intensive tasks. Therefore, they are disproportionately affected by the low farm mechanisation in the region. Yet, the solution may not be a simple one of developing women-friendly technologies. It may be more about ensuring that women have access to mechanisation services (particularly in women-headed households) and that women's high labour burden translates into actual demand for mechanisation (particularly in men-headed households). The latter is a more complex issue than the former, as it is about control over resources, intra-household decision-making processes and gender norms.

TK: In many parts of South Asia, increasing migration of men from rural areas to seek employment in urban centres or abroad has resulted in the progressive feminisation of agriculture. In Nepal, for example, many villages are now nearly devoid of farm working age men, leaving many agricultural tasks to women. But most farm machines are not designed

A female welder manufacturing a thresher in Hawassa, Ethiopia.
Photo: CIMMYT/Frédéric Baudron

with women users in mind. Machines may be overly large – even for some of the smaller two-wheel tractors – or lack the ergonomics that would make them easily used by women. We've begun to address these issues by developing equipment that can be used by women to reduce drudgery. Use of mini-tillers and knap-sack seed and fertiliser spreaders are good examples. Where women are less likely to operate machines themselves, as in Bangladesh, where social convention limits women's mobility outside the home or the village, we've worked to back women farmers to facilitate discussions with machinery service providers to get fair prices.

The full version of this article is available together with a wide range of sources for further reading/videos at
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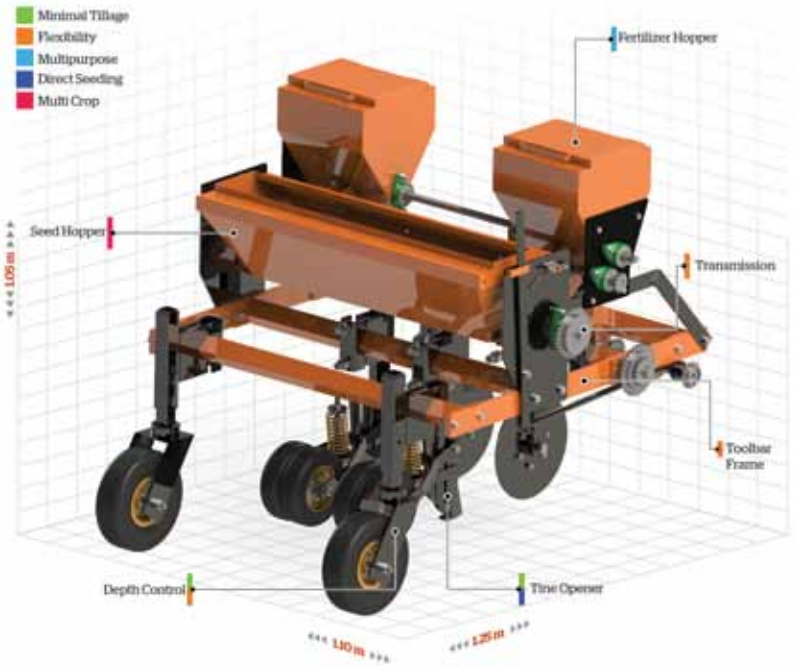

Computer-assisted design: Overview of a multicrop-multipurpose machine and its components to be operated with a 2WT.
Concept: Jelle Van Loon, Gabriel Martinez, Jesus López, Alejandro Klamroth