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Proceedings of the FAO Global Conference on Sustainable Agricultural Mechanization

Rome, 27–29 September 2023

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FOREWORD

Hunger and acute food insecurity are on the rise – 828 million people are suffering from hunger with millions more at risk. Around the world, over 3 billion people cannot afford a healthy diet. These numbers are alarming, and we must accelerate and scale up our actions to reverse these trends and achieve the Sustainable Development Goals (SDGs) by the 2030 deadline. This situation is exacerbated by the climate crisis, including changing rainfall patterns, intensifying droughts, and extreme weather events, as well as plant pests and diseases and other threats that are posing challenges to farmers and the way they produce.

There is so much at stake, and business as usual simply will not work. We need to innovate and leverage agricultural mechanization and automation as powerful forces to bring about change, but they must be sustainable and economically viable. Most importantly, farmers must be at the center of these collective efforts. Technological and innovative solutions must be developed by, with, and for farmers to sustainably transform global agrifood systems.

Agricultural mechanization is more than simply equipment and hardware. Combined with digital applications, satellite positioning, sensors and now with advanced data analytics and artificial intelligence, equipment and modern tools have become much leaner and more precise. They are becoming highly efficient and accurate in input-use, making water and fertilizer use more efficient. This is essential for building a better future, where we produce more with less for a more food secure future for all.

From 27 to 29 September 2023, FAO organized the first-ever Global Conference on Sustainable Agricultural Mechanization (GAMC) with the theme, "Efficiency, Inclusiveness and Resilience". It was an extraordinary convening, with over 8 500 participants of which nearly 300 joined in-person at FAO headquarters. Another first for FAO was the joint agricultural mechanization and livestock exhibition hosted in the FAO premises and showcasing over 40 different pieces of agricultural machinery of all sizes and scales and across different value chains.

The GAMC highlighted four key elements that are needed to prioritize actions, increase impact, strengthen technical networks, and overcome challenges for the sustainable development of agricultural mechanization:

1) Farmers need to be recognized as agents of change for sustainable agricultural mechanization. Solutions must align with the financial and environmental realities of farmers, their perspectives, needs and priorities, in particular those of small-scale farmers.

2) New and emerging technologies should be sustainable, economically viable, affordable, and accessible. The private sector plays a key role in driving this development through appropriate business models.

3) Policies must be in place to foster an enabling environment for agricultural mechanization to thrive and contribute to building efficient, inclusive, resilient and sustainable agrifood systems. These policies must be under pinned by scientific findings and supported by evidence.

4) Strategic partnerships are needed at global, regional, and national levels to enablethe mobilization of knowledge and innovations, to strengthen capacities and for theprovision of evidence-based solutions to develop appropriate practices and policiesat scale.

The GAMC culminated in the formulation of 15 forward-looking points for collective action. They highlight the urgency of mobilizing scientific, technical, and financial resources, championing knowledge-sharing through technical networks and scaling up the adoption of evidence-based sustainable agricultural mechanization practices, partnerships and policies. I encourage all stakeholders to join us in promoting and upscaling sustainable agricultural mechanization to realize its full potential for farmers and to keep pushing boundaries of what is possible in agrifood systems.

QU Dongyu
FAO Director-General

PREFACE

FAO organized the first-ever Global Conference on Sustainable Agricultural Mechanization (GAMC) from 27 to 29 September 2023, with the theme “Efficiency, Inclusiveness and Resilience”. The hybrid event allowed for a wide spectrum of stakeholders in sustainable agricultural mechanization to discuss and synthesize evidence on innovations and actions that strengthen the sustainable development of agricultural mechanization.

To plan and implement the GAMC, two governing bodies were created. The Organizing Committee (OC), chaired by FAO Deputy Director-General Beth Bechdol and co-chaired by Josse de Baerdemaeker, Professor Emeritus of KU Leuven. The OC provided strategic advice on all aspects of the conference and assisted in developing the technical programme, as well as selecting pertinent themes and prominent speakers. The GAMC Secretariat, led by Jingyuan Xia, Director of FAO's Plant Production and Protection Division (NSP) (2020-23), provided support to the organization of all core activities of the event. In addition, over 80 key players worldwide directly contributed to the success of the GAMC, as moderators of plenary sessions, chairs and co-chairs of parallel sessions, keynote presenters, key panelists and thematic speakers.

The two-and-a-half-day hybrid event at FAO headquarters in Rome, Italy, consisted of an opening plenary session, keynote address, high-level ministerial segment and closing plenary session. There were 12 parallel sessions; two on each of the six conference themes: mechanization for sustainable crop production; post-harvest and agroprocessing; climate change and resilience; digitalization and automation; supply chain and standards; and business models and multistakeholder engagement. In addition, there was a single session on the theme of enabling environment. Dialogue was fostered throughout the GAMC by alternating presentations and open discussions.

The conference convened over 300 participants in person and engaged over 8 500 virtual participants. Of these registrants, it is estimated that 31 percent were female; 33 percent came from research or academic institutions; 18 percent from the private sector; 10 percent from civil society organizations and NGOs; 10 percent from international organizations; 9 percent from farmers’ organizations and cooperatives; and 5 percent from the policy sector.

These proceedings, which are an important legacy for the conference, are composed of ten chapters:

- Chapter one contains the opening remarks of FAO Director-General, Dr QU Dongyu and the Undersecretary of State, Italian Ministry of Agriculture, Food Sovereignty and Forestry, Giacomo La Pietra, given the Organization’s and host country's high-level commitment, and proceeds with the keynote addresses of seven high-level speakers.

- Chapters two to eight include the abstracts of the presentations given by global experts and representatives of stakeholders in the thematic sessions.

- Chapter nine contains the statements delivered in the high-level segment by representatives of four countries, followed by concluding remarks by the FAO Director-General, Dr QU Dongyu.

- Chapter ten contains the call to action, composed of 15 points, drafted by the OC and enriched by contributions of the Members and various stakeholders.

The two parallel sessions on the theme of "Mechanization for crop production" were titled "Efficiency and productivity" and "Innovative technologies". The two parallel sessions of the theme of "Post-harvest and agroprocessing" were titled "Harvest and post-harvest" and "Agroprocessing". The two parallel sessions of the theme of "Climate change and resilience" were titled "Conservation agriculture" and "Precision agriculture". The two parallel sessions of the theme of "Digitalization and automation" were titled "Digital technology and ICT" and "Automation and AI". The two parallel sessions of the theme of "Supply chain and standards" were titled "Supply chains and services" and "Regulations and standards". The two parallel sessions of the theme of "Models and multistakeholder engagement" were titled "Inclusive business models" and "Multistakeholder engagement". In each parallel session, eight speakers were invited to make a presentation.

In the session on the theme of "Enabling environment", case studies were presented on: enabling sustainable agricultural mechanization through farmer-led initiatives and collaboration; transforming agriculture in Africa - farmer organization-driven strategies for an enabling environment in sustainable agricultural mechanization; government's role in enabling sustainable agricultural mechanization for economic growth and food sustainability in Zimbabwe; government's role in enabling sustainable agricultural mechanization for economic growth and food sustainability in the Philippines; fostering an enabling environment for sustainable agricultural mechanization from the perspective of supply chain actors; and agricultural mechanization systems in China.

All parallel sessions and the single session on farmers and enabling environment featured a moderated discussion during which the presenters responded to questions from the panelists, as well as online and in-person audience. These proceedings reflect the richness of the GAMC to focus attention on actions to promote sustainable agricultural mechanization as a key driver to transform agrifood systems.

As a means to streamline follow-up to the conference, 15 action points were proposed and agreed upon. These call to action could serve as the basis for promoting sustainable agricultural mechanization towards 2030 and beyond.

I am sure you will enjoy reading these proceedings.

Jingyuan Xia
Executive Secretary of the GAMC Secretariat
Special Advisor to FAO Director-General

ACKNOWLEDGEMENTS

The organization and implementation of the Global Conference on Sustainable Agricultural Mechanization (GAMC) was possible due to the invaluable support and commitment of many people. Particular thanks are owed to contributions from members of the two GAMC governance bodies: the Organizing Committee (OC) and the Secretariat.

The OC developed a programme covering the main conference topics, with proposals for the names of participants, while ensuring balance with respect to gender, geographic areas and stakeholder groups. The OC was skilfully chaired by FAO Deputy Director-General, Beth Bechdol, co-chaired by Josse De Baerdemaeker, Professor, KU Leuven, and vice-chaired by Josefa Leonel Correia Sacko, Bram Govaerts, Alessandro Malavolti, Louisa Parker-Smith and Chunjiang Zhao.

Deserving of special commendation are the members of the OC working groups who developed the draft programme for two parallel sessions dedicated to each of the seven conference themes: Mechanization for crop production (Rabe Yahaya and Regina Birner); Post-harvest and agroprocessing (Chakib Jenane and Tran Thi Dinh); Climate change and resilience (Akhylbek Kurishbayev and Mohammad Esmaeil Asadi); Digitalization and automation (Salah Sukkarieh and Cornelia Weltzien); Supply chain and standards (Ignacio Ruiz and Anshuman Varma); Business models and multistakeholder engagement (Saidi Mkomwa and Hiroyuki Takeshima); and Enabling environment (Geoffrey Mrema). The OC was deftly supported by FAO thematic session focal points, namely Ronnie Brathwaite, Mayling Flores Rojas, Buyung Hadi, Karim Houmy, Wilson Hugo, Shangchuan Jiang, Josef Kienzle, Haekoo Kim, Ivan Landers, Joseph Mpagalile, Hafiz Muminjanov, Godfrey Omulo, Santiago-Valle and Jingyuan Xia.

The FAO Plant Production and Protection Division, led by former Director, Jingyuan Xia, served as the GAMC Secretariat and was responsible for the core technical and organizational activities for the event. In particular, the contributions of Nadine Aschauer, Fenton Beed, Josef Kienzle, Haekoo Kim, Vuyo Maphango, Hafiz Muminjanov and Bruno Telemans, who oversaw the day-to-day running of the Secretariat, were invaluable. The Secretariat was also responsible for the publication of the conference proceedings.

Further, sincere recognition is owed to the 80 experts who served as chairs, key panellists and presenters of the different thematic sub-sessions, who ensured a wide diversity of global technical views and opinions on sustainable plant production.

The GAMC was organized as a hybrid event. This was a significant undertaking that demonstrates the resilience of FAO information technology infrastructure and the expertise of those who supported the Secretariat. Also, the sterling resourcefulness, patience and flexibility of FAO audio-visual, communication and multilingual interpretation teams were instrumental in creating the conducive atmosphere in which the conference was held. The work of all these behind-the-scenes professionals is gratefully acknowledged.


QU DONGYU
DIRECTOR-GENERAL
FAO
PATRIZIO GIACOMO LA PIETRA
UNDER-SECRETARY OF STATE
BETH BECHDOL
DEPUTY DIRECTOR-GENERAL
FAO
Food and Agriculture Organization of the United Nations
Global Conference on
Sustainable Agricultural Mechanization
nization

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ABBREVIATIONS AND ACRONYMS

AFA	Asian Farmers' Association for Sustainable Rural Development
AI	artificial intelligence
ANTAM	Asian and Pacific Network for Testing of Agricultural Machinery
APOSOLO	Portuguese Association for Conservation Tillage
AUC	African Union Commission
BEE	Bureau of Energy Efficiency (India)
BIS	Bureau of Indian Standards
CA	Conservation agriculture
CAU	China Agricultural University
CEMA	European Agriculture Machinery Industries Association
CEO	chief executive officer
CIMMYT	International Maize and Wheat Improvement Centre
CNY	Chinese yuan
CO_2	Carbon dioxide
COVID-19	coronavirus disease 2019
CSAM	Centre for Sustainable Agricultural Mechanization
CTRC	Conservation Tillage Research Center
DAMES	Directors and Heads of Agricultural Mechanization and Engineering Services
DSI	Department of Science and Innovation
DT	digital twin
EAGC	Eastern Africa Grain Council
EUR	euro
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
F-SAMA	Framework for Sustainable Agricultural Mechanization for Africa
GAMC	Global Conference on Sustainable Agricultural Mechanization

GCSLT	Global Conference on Sustainable Livestock Transformation
GDP	gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ha	hectare
hp	horsepower
ICT	information and communications technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
INRAE	Institut national de recherche pour l'agriculture, l'alimentation et le développement (France)
IOT	internet of things
IRRI	International Rice Research Institute.
IPPC	International Plant Protection Convention
ISO	International Organization for Standardization
KALRO	Kenya Agricultural and Livestock Research Organization
KeSEBAE	Kenya Society of Environmental, Biological and Agricultural Engineers
MAC	mining, agriculture and construction
Malabo	Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods
MAPA	Ministry of Agriculture and Livestock (Brazil)
NAFMP	National Agricultural and Fisheries Mechanization Programme
NERCITA	National Engineering Research Center for Information Technology in Agriculture (China)
NGO	non-governmental organization
NO_x	nitrogen oxides
NRF	National Research Foundation
NSP	FAO Plant Production and Protection Division

OC	Organizing Committee
OECD	Organisation for Economic Co-operation and Development
R&D	research and development
ReCAMA	Regional Council of Agricultural Machinery Associations
SARCHI	South African Research Chairs Initiative
SCEF	small-scale and emergent farming
SCAU	South China Agricultural University
SDG	Sustainable Development Goal
SDG 1	End poverty in all its forms everywhere
SDG 2	Zero Hunger
SDG 3	Ensure healthy lives and promote well-being for all at all ages
SDG 12	Ensure sustainable consumption and production patterns
SDG 13	Take urgent action to combat climate change and its impacts
SME	small and medium-sized enterprises
SoNaMA	Société Nationale de Mechanisation Agricole (Benin)
UAV	unmanned aerial vehicle
USD	United States dollar
WFO	World Farmers Organization
WFP	World Food Programme


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Chapter 1

Opening and keynote address plenary session

1.1 Opening remarks

QU Dongyu
FAO Director-General

We are making history!

These conferences at FAO are part of our bigger plan for building a dynamic FAO for a better world based on the four Rs: the first phase was "reform" and "recovery", and now we move to the second phase of "rebuilding" and "renaissance".

This week is of critical importance as we bring the four betters to the centre of our discussions with these two first-ever Global Conferences on Sustainable Livestock Transformation and on Sustainable Agricultural Mechanization. Both need science and innovation, investment and political commitment.

We are here, together, to support our commitment to transform our agrifood systems to be more efficient, more inclusive, more resilient and more sustainable, and to shape a food-secure world and better future for all.

So much is at stake at this particular moment. Hunger and acute food insecurity are on the rise, with millions more at risk. There are 828 million people suffering from hunger. And more than 250 million people are facing acute levels of hunger in 58 countries and territories globally, with many on the brink of starvation.

We need to ask ourselves why this is happening – this is a question that should come not only from our heads, but also from our hearts.

Around the world, over three billion people cannot afford a healthy diet.

These are alarming numbers, and we must take steps to reverse these trends. We need actions to address these numbers and reduce the numbers, otherwise they remain only numbers!

The world population also continues to rise. This means we will need to produce 50 percent more food by 2050 than we did ten years ago to feed more people.

Less than 30 years is NOT a long time to go!

We need to produce more (more production, more diversity and higher quality) with less (inputs, negative impacts and communicable diseases).

We need to plan better to ensure a better life for the billions of children that are still to come into this world – we need to ensure they have more than what we had in our childhood.

We need to start by changing ourselves, the impacts on our bodies and our impacts on the environment. We need to start by correcting our own mistakes as human beings.

We are also facing extraordinary challenges linked to diminished natural resources, degraded soils, water and environmental worsening, and the many other impacts of the climate crisis and socioeconomic disorders.

Changing rainfall patterns, intensifying droughts and extreme weather are challenging farmers and the ways they produce.

Business as usual just simply will not work.

We need to innovate and be well equipped – for this reason we need adequate investment to ensure appropriate equipment. We cannot depend on nature alone. And for this, we need concrete action.

Mechanization and automation are powerful forces for change, but they must be sustainable and economically viable.

Around the world, sustainable agricultural mechanization is advancing at a rapid pace.

Machinery is not only machines with artificial intelligence (AI) equipped tools, but they are also much leaner and more precise. Business and financing models are more economically viable. New and better jobs are being created, and agrifood systems are more and more attractive.

Innovation developed by – and for – farmers is what is redesigning and transforming the agricultural sector.

Cutting-edge technologies, such as satellite systems, robotics, AI and automated equipment are also shaping the future of farming and food systems.

Across the world:

- drones are monitoring and protecting crop health;
- robots are identifying and removing weeds, as well as pruning and picking fruit;
- automated tractors are planting, applying fertigation, harvesting and handling post-harvest tasks with remarkable precision and efficiency;
- sensors and satellites are providing data-driven insights for improved decision-making by farmers; and
- e-commerce and infrastructure in rural areas are developing to make domestic and international markets directly accessible – for a true “farm to fork” process.

Equipment is also becoming safer and more environmentally sound, driving us towards more sustainable and efficient agricultural practices.

If we harness innovation, including digitalization, we can unlock even greater potential across our agrifood systems.

But as we look to the future, we need to make sure that all these advanced and emerging technologies leave no one behind – especially farmers in rural areas and small towns.

This means we must work with and for smallholder farmers, as well as food providers, to ensure that these technologies and equipment are adaptable to their local contexts.

Equipment must be available, accessible and affordable, and it must not contribute to widening the digital divide.

We must also not neglect women and young people, who have the potential to revolutionize agrifood systems. Today, some tractors are being customized specifically for women operators – this is a step in the right direction.

If we close the gender gap in farm productivity and the wage gap in agrifood systems, we could increase global gross domestic product (GDP) by USD 1 trillion and reduce the number of food-insecure people by 45 million.

And if we involve young people, we will see even greater results and revitalize traditional villages.

Young people are our future and true innovators on the ground to drive ingenuity in agrifood systems through the development and application of innovative solutions. It is part of human nature for young people to want to move out of rural areas towards areas that will offer them more opportunities.

Dear Colleagues,

We need to continue working together to revolutionize agrifood systems to achieve food security for all and to safeguard our planet.

This conference has convened a wide range of partners to ensure that all voices are heard, including the private sector, which is leading research, manufacturing and investment in this sector, especially in agricultural equipment.

FAO has four key objectives for convening this conference:

- One: to increase awareness of the contribution of sustainable agricultural mechanization to achieving the Sustainable Development Goals (SDGs);
- Two: to share information and knowledge on the strategic direction of, and technical developments in, mechanization around the world;
- Three: to highlight FAO technical expertise and convening power to support our Members in leveraging sustainable agricultural mechanization as a pillar of their agrifood-system transformation; and
- Four: to provide a professional platform to strengthen technical networks and dialogues on mechanization.

These objectives go beyond this conference. We need to also commit to three key steps over the next three days:

- First: we need to establish priorities for mobilizing and pooling scientific, technical and financial resources to promote sustainable agricultural mechanization;
- Second: our discussions must lead to effective recommendations and action plans, and thereafter identify our key partners to support Members in implementation, to guide our work forward towards true sustainable agricultural mechanization; and
- Third: we must continue to convene technical fora to drive advancements in agricultural mechanization covering "from soil to stomach" through innovation and technologies.

We must push the boundaries of what is possible in agrifood systems.

FAO is committed to leveraging the momentum generated by this conference and to transforming our discussions into action to shape a better future for food and agriculture through better production, better nutrition, a better environment and a better life, leaving no one behind.

Agriculture starts with better production.

Thank you.

1.2 Opening statement

Patrizio Giacomo La Pietra
Undersecretary of State, Italian Ministry of Agriculture, Food Sovereignty and Forestry

FAO Director-General QU Dongyu,
Deputy Director-General Beth Bechdol,
Honourable Ministers,
Ladies and Gentlemen,

I am pleased to participate in the opening session of the first Global Conference on Sustainable Agricultural Mechanization.

I thank FAO for organizing this event, bringing together the academic world, representatives of international organizations, governments and civil society at the same table on a topic of extreme importance.

The conference gives us the opportunity to analyse the role of agricultural mechanization in promoting sustainability, and is in continuity with the Summit on Food Systems, convened by the United Nations Secretariat and hosted by Italy, in collaboration with FAO, the World Food Programme (WFP) and the International Fund for Agricultural Development (IFAD).

In all international fora, the issue of food security is at the centre of the debate, as we are still far from achieving the zero-hunger objective. We are witnessing a worsening of insecurity in various countries as a consequence of ongoing conflicts in various regions of the world and, most recently, the Russian war of aggression towards Ukraine.

For this reason, it is necessary to continue working together to find adequate solutions. Italy will continue to do its part also by leveraging the Presidency of the Group of Seven, which it will assume in 2024, and during which Italy would also like to count on the technical support of FAO.

Combining sustainability and agricultural productivity will be the main objective in the coming years. Mechanization will certainly be able to play a key role in reducing the environmental impact of agriculture. Mechanization is a precious tool for reducing soil degradation and decreasing the use of chemical substances harmful to flora and fauna. Among other things, the use of new equipment and sensors can favour a clear reduction in the use of pesticides.

A significant impetus to the modernization of agriculture and the improvement of production quality can be provided by new technologies, digitalization and precision agriculture.

Furthermore, it is essential to support the introduction of innovative and higher-performance machinery, which can lead to emissions reductions.

For the reasons I have mentioned, this conference is strategic for highlighting different aspects of mechanization.

I hope that paths can emerge from the debate so that mechanization can contribute more to the objectives of sustainable development, and that there can be a reflection on research in the agricultural machinery industry to meet the needs of different types of agriculture and different models of organization.

We need to promote more sustainable agricultural mechanization at global and local level that takes into account the territorial context and the different needs of farmers.

What happens in Italy?

Italy has always been careful to promote sustainable agriculture practices in line with the objectives of the 2030 Agenda, and mechanization has played a fundamental role in making Italy’s agricultural sector increasingly resilient and sustainable.

In this regard, the Government of Italy has adopted two important support tools aimed at the introduction of innovative and sustainable machines, with a total allocation of EUR 725 million to improve the sustainability of production processes.

Italy has a national agricultural machinery industry, which in 2022 had an export value of EUR 7.3 billion, an increase of 16.7 percent compared to 2021. The national agricultural machinery industry offers a diversified range of products, as producers create machinery suitable for any type of territory, precisely adapted to the different needs and varieties of the country's agricultural systems.

At the international level, Italy wants to make its own contribution to supporting agricultural development in low-income countries with high growth potential through the use of sustainable mechanization, with a focus on what is potentially adaptable to the context and needs of small farmers in developing countries.

Ultimately, we are ready to promote the exchange of knowledge and encourage the training of farmers at an international level so that they can exploit the full potential of available technology.

I conclude my speech by wishing everyone a fruitful debate.

Thank you.

Keynote presentations

1.3 Mechanization for sustainable agrifood systems

H.E. Josefa Sacko

Commissioner for Agriculture, Rural Development, Blue Economy and Sustainable Environment, African Union Commission (AUC)

Dr QU Dongyu, Director-General, FAO,
My dear sister and moderator, Maria Helena Semedo, Deputy Director-General, FAO,
Beth Bechdol, Deputy Director-General, FAO,
Patrizio Giacomo La Pietra, Undersecretary of State, Italian Ministry of Agriculture, Food Sovereignty and Forestry,
Excellencies,
Distinguished Participants,
Ladies and Gentlemen,

On behalf of the African Union Commission, I am delighted to be invited by FAO to deliver a keynote address on a very topical issue, "Mechanization for sustainable agrifood systems" at this first-ever Global Conference on Sustainable Agricultural Mechanization (GAMC), hosted at FAO headquarters in the beautiful city of Rome.

Since the United Nations Food Systems Summit in 2021, agrifood system transformation has been high on the policy agenda to achieve the Sustainable Development Goals by 2030. Innovations, including agricultural mechanization, which is spreading rapidly in the global South and fundamentally changing the character of agrifood systems, are playing a key role in this transformation.

For understandable reasons, my statement will focus on Africa. Apart from being the geographical focus of my mandate as African Union Commissioner, the continent is lagging behind in mechanization, as is also the case for the use of several other agricultural inputs such as seeds, finance and fertilizer.

Africa ranks at the bottom of the six continents in mechanized agriculture. While North America and

Europe are fully mechanized, FAO and the African Union Commission (AUC) estimated in 2018 that, despite signs of rapid mechanization in selected areas in Africa, only about 10 percent of its crop farmers use tractors, which is usually the first step to mechanized farming. It is not a surprise then that the value added per worker in agriculture in North America is 66 times higher than that of sub-Saharan Africa.

Sustainable agricultural mechanization is seen as an indispensable pillar for ending hunger in Africa, as stated in the 2014 Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods and in SDG 2. Commitment number 3 of the Malabo Declaration identifies agricultural mechanization as a key factor in doubling agricultural productivity levels by 2025. The resolution specifically calls for creating and enhancing appropriate policies, institutions and support systems to facilitate "suitable, reliable and affordable mechanization and energy supplies".

Doubling agricultural productivity and eliminating hunger and malnutrition in Africa by 2025, as enshrined in the Malabo Declaration, will not be realized unless mechanization is accorded the utmost importance. The African Union Specialized Technical Committee on Agriculture, Rural Development, Water and Environment therefore requested the AUC and FAO to develop the Framework for Sustainable Agricultural Mechanization in Africa (F-SAMA) through an Africa-wide consultative process.

I was delighted to launch the F-SAMA together with my sister, Maria Helena Semedo, on 5 October 2018 at the Twenty-sixth Session of the Committee on Agriculture held in Rome. The document includes ten priority elements geared towards informing policy and decision-making in African Union Member States, the Regional Economic Communities in Africa, and the wider development community concerned with agricultural development. These priority elements highlight the significance of mainstreaming F-SAMA in their overall national and regional agricultural development programmes. They also include some fundamental principles based on lessons learned from our dismal history of mechanization that has led to machine dumps in several countries. Mechanization in the twenty-first century must be built along the entire agricultural value chain. It must be private-sector driven, environmentally compatible and climate smart. It must also be economically viable and affordable, especially for small-scale farmers who constitute the bulk of African farmers. It is vital that it targets women, who bear the brunt of African agriculture. And finally, mechanization must target young people, specifically by making agriculture a more attractive choice for employment and entrepreneurship.

Since the launch of the F-SAMA in 2018, FAO, the AUC and African Union Member States have strived to operationalize the Framework by implementing various activities aimed at creating awareness on F-SAMA and strengthening networking and linkages. These include 10 webinars conducted over two years, in both English and French. Directors and Heads of Agricultural Mechanization and Engineering Services (DAMES) from various African countries and other key stakeholders have been motivated to establish operational structures for the implementation of the F-SAMA at subregional and regional levels.

FAO has also supported ten African Union Member States (Benin, Chad, Ghana, Liberia, Mali, Sierra Leone, Togo, United Republic of Tanzania, Zambia and Zimbabwe) to formulate or revise national sustainable agricultural mechanization strategies drawing from F-SAMA.

The African Union will continue to work with FAO to popularize F-SAMA and support Member States to adopt it.

Meanwhile, the AUC, under its erstwhile chair, H.E. Dr Nkosazana Dlamini Zuma launched a campaign to "retire the handheld hoe to the museum" during the Twenty-fifth Ordinary Session of the Summit of African Union Heads of State and Government held in South Africa in 2015.

As a symbolic gesture, Madam Zuma delivered a power tiller to each African Head of State and Government to emphasize the importance of removing drudgery from agriculture, thereby improving labour productivity, especially for women, with the hope that mechanization of agriculture in Africa will be achieved within the next 10 years.

I have committed myself towards taking this laudable initiative forward since my election.

My department, in collaboration with several partners, held the Inaugural West African edition of "Sending the Hoe to the Museum" on 14 and 15 October 2019 in Bobo Dioulasso, Burkina Faso, in commemoration of International Rural Women Day. The event, which attracted over 2 000 rural women, is furthered and co-hosted by different subregions in Africa every year to create momentum for the initiative. Unfortunately, COVID-19 slowed us down, but we were still able to commemorate the 2022 edition in Mozambique on women in fisheries.

Excellences, Ladies and Gentlemen,

To conclude, agriculture is crucial to Africa's development, but needs increased mechanization to boost economic productivity, reduce post-harvest losses and meet growing demand for food. The time is ripe for all stakeholders to develop a new paradigm for mechanization in Africa drawing on F-SAMA. There are still several challenges, the most prominent being the lack of up-to-date data from Member States on what is being implemented towards operationalization of F-SAMA and the status of agricultural mechanization at the country level. This is not just an African problem but a global challenge.

It is in this regard that I am making a strong appeal to FAO to revert to producing data on mechanization, which the organization has discontinued. It will be helpful if the data can be disaggregated by gender so that we can monitor the progress in pursuit of our goal of retiring the handheld hoe to the museum and other gender-based initiatives. Thank you for your attention.

1.4 Farmer-led sustainability, resilience and climate-smart agriculture

Robert Bonnie

Undersecretary for Natural Resources and Environment, United States Department of Agriculture

The approach of the United States of America on sustainability and sustainable mechanization, nationally and across the globe, addresses two significant challenges. First, there is the issue of food and nutritional security. Second, how do we provide the food and fibre that society needs in a growing world when food production is made more difficult due to extreme weather? While we often talk about sustainability and climate change, we sometimes forget the importance of productivity itself. Maintaining productivity is crucial, not only to feed a growing world but also to reduce pressure on biodiversity.

In the United States of America, there is a concerted effort to ensure continued productivity while improving the carbon footprint of agriculture. More and more farmers and ranchers are embracing this approach. We see an important alignment between the types of practices that can benefit agriculture, improve soil health and nutrient management. In our policy discussions, we aim to leverage this alignment. However, it is essential to acknowledge that implementing these practices may come with costs and risks for farmers and ranchers. Still, there are opportunities to capitalize on this alignment.

In the United States of America, there is some scepticism about what climate policy will mean for agriculture and how we will deploy climate-smart agriculture practices across the nation. The approach we take and how we implement it is just as important as what we do. Agriculture can embrace technology and innovation to make this transition smoother. Sustainable mechanization plays a crucial role in this context.

As we think about climate and technology, it is clear that the use of technology is increasingly important. Precision agriculture has been widely adopted in the United States, not just because it is climate-smart but also because it improves producers' bottom lines. Additionally, sustainable mechanization in the dairy industry allows for tracking the efficiency of individual cattle, including milk production and methane emissions. Technologies such as electronic fencing and grazing management promote sustainable grazing systems, which improve soil carbon and overall soil health. These technologies enable us to monitor soil productivity and carbon content more effectively.

To incentivize these practices, we have two flagship efforts. First, the Inflation Reduction Act, passed by Congress a year ago and signed by President Biden, provides approximately USD 19.5 billion in new resources for climate-smart agriculture and forestry in the United States of America. This funding supports the deployment of climate-smart practices at scale and includes USD 300 million for measurement, monitoring and verification to ensure alignment with scientific guidelines.

Our second major effort is the Partnership for Climate-Smart Commodities, initially funded with USD 1 billion. However, we received over USD 20 billion in proposals, and we will ultimately allocate around USD 3 billion. This programme focuses on deploying climate-smart practices at scale, with a strong emphasis on measurement, monitoring and verification. We are committed to ensuring equity in these programmes, making sure that small- and medium-sized farmers and historically underserved farmers can fully participate.

Lastly, we are exploring ways to create value for agriculture and reward producers through market mechanisms. While government funding is vital, our long-term goal is to attract more private sector investment. We aim to build something that has agriculture's fingerprints on it and is supported by agricultural and forestry communities. We believe this approach will garner more political and consumer support for climate-smart initiatives in the long term, as we can demonstrate their effectiveness for both agriculture and the environment. Thank you for listening.

1.5 Climate change and mechanization

Bram Govaerts
Director-General, International Maize and Wheat Improvement Center (CIMMYT), Texcoco, Mexico

Agricultural mechanization, widely viewed as a necessity for agricultural transformation, refers to the process of introducing a technology or farm tool that increases labour efficiency, reducing drudgery while enhancing the precision of the operation performed. Nevertheless, ensuring that this transformation is a positive one for farmers and for their farming systems globally goes beyond merely introducing large-scale, cutting-edge equipment with the aim of accelerating the development of the agricultural sector. In fact, for the myriad, intricate farming systems often practised by smallholder farmers or rural poor in developing countries, making a sustainable transition from traditional farm machinery tool systems to modern technology-based agriculture requires considering the scale of operations, the socioeconomic context and the development of tailored solutions. Options for smallholder farmers are often limited, and even more so when male family members migrate to urban centres in search of more remunerative employment options. Women farmers are then left in charge of rural households, and young people are discouraged due to the perceived high labour demand and low income opportunities.

The work on agricultural mechanization at the International Maize and Wheat Improvement Center (CIMMYT) starts from a systems approach and focuses on several key areas aimed at increasing the productivity and sustainability of farming practices, in response to the specific context and scale of farm operations.

First, work focuses on the unique needs of smallholder farmers through collaborative research and the development of tailored solutions and equipment for time-sensitive and high-drudgery activities. Climate-smart options and precision tools are developed and evaluated from the perspective of the farmer, in terms of required skill sets and capacities, cost–benefit and demand. “Climate smartness” of the proposed equipment considers the region’s climate vulnerability and how it leads to the sustainable use of resources available locally, including soil, nutrients, water, energy and time.

Still, the broader challenge is not just to develop new machinery or equipment but to support the development of conducive market environments for scaling mechanization in target countries and farming communities. CIMMYT works on facilitating the roll-out and sustained scaling of farm machines, supporting farmers to overcome challenges in adopting improved crop management practices and investment constraints to have access to appropriate equipment. This work requires active engagement with machine value-chain actors and includes business-model development, generation of market intelligence and capacity building on the use, operation, maintenance and manufacturing of equipment, as well as increasing skills for providing services to enable local actors to create a healthy machinery environment. It involves recognizing and gaining a better understanding of actual or perceived factors that hinder adoption, such as changes in employment, effects on social concerns and environmental factors. Transparent and evidence-based findings on the benefits and the potential costs are essential for local actors to make informed and balanced decisions on where and for whom mechanization makes the biggest difference.

Using the Scaling Scan framework, CIMMYT has systematically analysed the main obstacles to large-scale adoption of farm mechanization to support rural development initiatives in low- and middle-income countries. The evidence from projects in Mexico, Zimbabwe and Bangladesh shows that factors hampering scaling efforts are the lack of adequate finance solutions to set up models around mechanization service provision and insufficient collaboration between value-chain actors to foster and strengthen farm-machinery entrepreneurs. Addressing these issues goes beyond working in the field. It includes the need to analyse markets for demand, evaluate the socioeconomic and technical capacity of smallholder farmers and actors of the entire value chain.

It is also good to consider that mechanization aims at replacing long-standing, traditional or dominant practices that are engrained in farming communities and are often difficult to change. Therefore, when introducing machinery or equipment in a particular setting, there is a need to identify existing practices that will be reduced to accommodate them, while also seeking ways to engage young people in agriculture and create profitable jobs in rural communities.

Digitalization and automation of farm tools can help farmers overcome the steep learning curve of the transition from conventional farming practices to sustainable management. These tools can be integrated with decision-support systems that calibrate, measure and guide farmers to take the right actions in the field.

Over the past decade, CIMMYT has actively engaged in partnerships with international aid agencies and governments across Latin America, Africa and Asia. Some of these ventures include MasAgro in Mexico, where CIMMYT has developed over 40 scale-appropriate machine prototypes to be used throughout the production cycle, from land preparation to post-harvest.

With support from the Australian Centre for Agricultural Research, two-wheel tractor machine bundles were assessed from a socioeconomic perspective in East Africa. In addition, a network of mechanization experts, practitioners and service providers in 15 countries in Africa and Asia aims to steer scaling efforts by building on former mechanization investments locally with support from the German Agency for International Cooperation (GIZ) and FAO. Also, a longstanding relationship with the United States Agency for International Development in South Asia has greatly supported the roll-out of machine-service-provision models and small-scale irrigation solutions.

CIMMYT will continue following this path, improving its designs, enhancing builder and operator training with advanced digital tools, broadening its network of service-management platforms and offering modern farm machinery solutions for the poorest of the poor. Awareness and links between stakeholders must be improved, while technical support, training and access to finance is required at all levels. Government policies should facilitate local manufacturing with an emphasis on quality and cost-effectiveness, including updating and upgrading private-sector manufacturing enterprises.

With this collaborative and transdisciplinary approach, CIMMYT strives to catalyse positive rural transformation by leveraging yield-enhancing practices, entrepreneurship skills and market-participation endowments of sustainable mechanization and, as a result, promotes more inclusive and sustainable agricultural systems that benefit farmers and communities globally.

1.6 Farm power and energy source innovations

Alessandro Malavolti
Vice-President, European Agriculture Machinery Industry Association (CEMA)

CEMA is the association representing the European agricultural machinery industry. With 11 national member associations, the CEMA network represents both large multinational companies and numerous small and medium-sized enterprises (SMEs) in Europe active in the sector.

The industry comprises about 7 000 manufacturers, producing more than 450 different types of machines, with an annual turnover of about EUR 40 billion and 150 000 direct employees. CEMA companies produce a wide range of machines that cover various activities in the field, from seeding to harvesting, as well as equipment for livestock management.

Our companies are eager to showcase machinery that can improve sustainability, and thus did not hesitate to participate in the exhibition of agricultural machinery associated with the GAMC. These machines are designed to increase sustainability in agriculture and combat hunger. This shared ambition can only be achieved through smarter farming technology and practices, combining mechanical and digital technologies with advances in seed, pesticide and fertilizer technologies. Recognizing farmer needs must be central to our thinking.

Every country, region and town has different agricultural practices, traditions and needs. CEMA, as the world's largest agricultural machinery exporter, understands Europe's diversity. Our companies serve farmers globally, adapting their 450 different machines to meet the unique needs of each farmer with tools ranging from sophisticated to basic.

What stands out in enabling farmers to make agriculture more sustainable is the need for profitability. Farming is a private business and, while governments can invest, it only works when private investment in sustainable technology is made possible. This is not easy, given the challenges of climate change, market volatility and storage issues.

We are grateful for the support of governments and international agencies to farmers, but with many agricultural equipment companies here today, we invite you to consider machinery's role. Sustainability can have multiple meanings when viewed holistically, which includes enabling farmers to achieve long-lasting profitability and to reduce their environmental footprint, helping them to make a positive impact as part of a circular economy.

To achieve this, we must reduce our dependency on fossil fuels. Our industry is working on a variety of technologies to reduce carbon footprints. First, all available options must effectively be used on each farm. Among these options, the use of smart machinery can improve efficiency in farm-production processes. Electrification and the use of renewable and low-carbon fuels are also essential. Tractors and other equipment are built to last, with an average lifespan of 40 years. Some tractors from the 1960s are still working, powered by combustion engines. There is currently no replacement technology available. We need to find a mix of sustainable technologies suitable for each region and farm size.

To reduce CO_2 emissions, it will necessary to transition from combustion engines to renewable and low-carbon fuels, such as high energy output fuels, which include liquid and biomass fuels, such as green hydrogen and e-fuels.

For the short and medium term, this is feasible for smaller and less powerful equipment used in hobby farming or gardening. However, for mid- and large-scale machines, this technology is not yet available. In the next decade, technological developments may address some of the challenges, such as machine weight.

Farmers are key players as both producers and consumers. They have the potential to generate energy from solar panels. Our industry contributes to this energy-source innovation and sustainability by developing machines that save fuel, time and money. We also provide precision technology to save farmers money and preserve soil. Healthy soil can capture CO_2 and contribute to climate change mitigation.

Climate change poses a threat to global sustainability, and we are committed to making a positive impact. However, we cannot achieve this alone. We call for collaboration from everyone here, including governments and non-governmental organizations (NGOs).

1.7 Digitalization for agrifood system transformation

Chunjiang Zhao
Professor and Chief Scientist, National Engineering Research Center for Information Technology in Agriculture (NERCITA), Academician of the Chinese Academy of Engineering (CAE), Beijing, China

Background

Global climate change, population growth and other challenges continue to threaten food security, which requires us to find solutions to improve agricultural productivity and ensure sustainable development. Digitization and mechanization in agriculture can accelerate the transformation to more efficient, inclusive, resilient and sustainable agrifood systems. Smart agriculture is an innovative production mode that integrates good agricultural practices, biotechnology, information technology, intelligent machinery and equipment.

Smart agriculture strategy in China

China faces challenges, such as a lack of arable land and freshwater resources, and low resource-use efficiency.

Smart agriculture has been included in the national "14th Five-Year Plan" as the future development direction of agriculture in China. The strategic objectives and missions are to strengthen human capacities through the application of digital technology, and to replace human labour and animal power with machinery to create a more sustainable agrifood system. China promotes the development of smart agriculture for agrifood-system transformation by taking the following actions:
(1) strengthening village information infrastructure;
(2) formulating standards and specifications;
(3) promoting innovation of smart agricultural technology;
(4) creating smart agriculture application scenarios;
(5) building different types of talent; and
(6) designing supporting policies and countermeasures.

Progress of smart agriculture

The development of smart agriculture in China has made significant progress as follows:

1. Laser land levelling. Laser land levelling is a method to improve irrigation efficiency and facilitate more uniform distribution of irrigation water. Current laser land levelling systems include electrohydraulic-driven scraper systems, automatic controlling systems and laser transmitting/receiving systems. In the field, farmland levelling can reduce water use by up to 30 percent and reduce irrigation costs by 60 percent.

2. Precision planting. Precision planting is an effective technology that can increase yield per unit of land area by ensuring a high seedling-emergence rate, consistent seedling spacing and easy management. However, the application of precision-planting technology is not yet widespread in China due to its cost, the reliability of planters and technological limitations. To implement precision planting, integrated technologies, such as seed bed environment sensing, precise sowing control and sowing monitoring are essential. NERCITA has developed precision seeding and unmanned seeding technology by equipping electrically powered devices with precision seeding-control systems, seed-reinforcement technology and monitoring systems. Through field verification, precision-planting systems can increase seed spacing uniformity to more than 96 percent.

3. Precision fertilization. Soil nitrogen detection can be done on-site using the laser-induced breakdown spectroscopy method, which consists of focusing a high-energy laser pulse on the sample surface to create a transient plasma and resolving the emission with a high-resolution spectrometer. This method can overcome the shortcomings of time-consuming and costly traditional laboratory analysis.

Spectral technology can be used to diagnose the nutrient status of the crop canopy, providing a decision-making basis for precision fertilization. An unmanned aerial vehicle (UAV) carrying microimaging spectrometer and satellite remote sensing technology can be used for crop nutrient diagnosis of small- and large-scale farmland. An easy-to-use portable crop health monitor, named CropSensor, has been developed to be operated by farmers in the field.

With variable rate technology, precision prescription fertilization can be achieved with the support of agricultural machinery navigation and intelligent control technology. Precision fertilization implemented by digital agricultural machinery is an effective way to improve fertilizer-utilization rates and reduce fertilizer use by 20 to 30 percent for rice compared with traditional fertilization methods.

4. Precision spraying. Internet of things (IOT) technology is used for integrated monitoring and dosage control of pesticides, either by onboard or remote terminals. pray booms can incorporate automatic navigation technology in order to operate autonomously, with automated controls for spray boom height, folding and unfolding, and breakpoint continuation spraying. The distribution of droplets on the crop canopy for key spraying parameters of the boom sprayer is studied, and a flexible windproof deflector is developed to reduce pesticide drift. Target-oriented weeding is achieved by visual target technology. In cabbage production, pesticide use is reduced by 66 percent without reducing yields as compared to weeding.

5. Application of IOT and GNSS in agricultural mechanization. IOT and the global navigation satellite system (GNSS) are widely used for operating agricultural machinery to ensure machinery efficiency by monitoring operation areas, quality, working conditions and energy consumption, among other parameters. The agricultural machinery IOT is now the most popular technology among farmers in China. Machines incorporating detectors, with different integrated sensors, GNSS and wireless communication, are used to monitor tillage and subsoiling depth, sowing quality, fertilization, pesticide spraying, harvest, etc. Data monitoring is useful for the government to allocate financial subsidies, manage agricultural machinery cooperatives, protect the rights and interests of machinery operators, and defend the interests of farmers. The use of GNSS in agricultural machinery can significantly improve the quality and efficiency of operations in the field. An autonomous tractor system based on China's BeiDou Navigation Satellite System was developed to reduce driver workloads and improve machinery efficiency. Problems in using the automatic navigation system under complex conditions, on farmland with varied topography and at high speeds were solved.

Summary and discussion

Mechanization, digitization, automation and intelligence in smart agriculture are essential to establish more efficient and sustainable agrifood systems. China has made significant progress in smart agriculture while facing the following challenges:

1. Farmers are not willing to invest in smart agriculture because of additional input costs and low income from agriculture production. In this case, government subsidy policies and other favourable policies can encourage farmers to implement smart agriculture practices;
2. Smart agriculture technologies do not meet the practical needs of farmers with poor educational backgrounds. More focus is needed on the demand for practical and low-cost technology products by farmers rather than on academic research; and
3. The small scale of farmland. There are between 230–250 million households engaged in small-scale farming in China (0.53 ha per household). These farmers need more effective smart agriculture solutions focusing on compatibility and adaptability for small-scale farming, not based on increasing equipment size. Promotion of smart small-scale farming includes consolidation of land use, coupled with the development of appropriate machines, systems, trusteeship services and policies.

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1.8 Automation trends in agriculture

Louisa Parker-Smith
Director, Global Sustainability, AGCO

AGCO designs, manufactures and distributes agricultural machinery and technologies, including well-known brands such as Fendt, Massey Ferguson, Valtra and Precision Planting. Since motorized mechanization first became prevalent in the 1900s, trends in agricultural machinery have often focused on increased power and size. This presentation highlighted how current trends in automation are significantly more focused on data and precision, which presents both a challenge and an opportunity for the industry.

A significant challenge recognized by all is the growth of the world's population. There will be less arable land available per capita in the future. Farmers will face increasingly difficult conditions regarding the management of inputs such as fuel and fertilizer, progressing environmental regulations, increasing production costs, optimal windows for planting and harvesting impacted by climate change and constraints around the availability of skilled labour.

Yet farmers will have to produce more under these increasingly challenging conditions, which emphasises the need for efficiency, leading to an increased focus on automation and autonomy, particularly at the precision level.

When addressing these challenges, one must consider a broader perspective integrating the challenge of farmer yields and profitability with the larger challenges of climate change, biodiversity loss and poverty. In July of this year, at the United Nations Food Systems Summit, it was explicitly mentioned that investing in research, data, innovation, technology capabilities and increased business engagement are crucial to shaping the sustainability of food systems. We need solutions that place agricultural technology at the heart of sustainable agriculture.

As the challenges have grown in scope and magnitude, AGCO has invested more in the agriculture of the future. In the last decade, approximately EUR 3 billion have been devoted to research and development (R&D). In the decade to come, a significant proportion of AGCO's R&D expenditure will focus on clean technology – including electrification, alternative propulsion and future fuels. AGCO has been developing machines that are not only automated but autonomous. The difference is that automated processes adjust conditions automatically throughout the field and reduce the operator's effort, while autonomous machines can produce outcomes as good as or better than even the most-skilled human operators.

As we transition from automated to fully autonomous machines, we change the traditional construct that every farm has used up to this point, namely that one operator operates one machine. Within this boundary, machines have become larger and more complex to maximize the productivity of each person, with limited understanding of the resulting consequences, especially with regard to environmental impact.

Autonomy offers a wide range of opportunities, prompting us to consider the concept when designing new machines to address emerging challenges in the agricultural industry, including the need for:

- smaller, more purpose-built machines for each n-field operation;
- machines that are easily adaptable to alternative energy sources;
- reduced waste through correct placement of chemicals and fertilizers;
- reduced machine costs;
- reduced complexity of seasonal workforce;
- reduced (or eliminated) human error;
- high-precision treatment of individual plants or field sections; and
- minimized soil compaction and plant damage.

The development of fully autonomous machines requires cooperation among various technology players in the market, covering areas such as guidance, advanced sensing, artificial intelligence, obstacle avoidance and more.

The triple win achieved by automated and autonomous machines is increased farmer profitability and productivity and a more sustainable environment.

Examples of autonomous agriculture technology under development at AGCO:

- For soil management, Radicle Agronomics is the world's first fully automated soil laboratory. It simplifies the workflow for agronomists, reduces steps and allows for more accurate soil sampling.
- SmartFirmer technology collects real-time data while a tractor moves over the field for seed planting, analysing over 32 000 data points every second to optimize seed placement, moisture levels, even the choice of the hybrid of the crop, to ensure maximizing the yield for every seed that is planted, without any input by the operator.
- The Fendt Momentum planter automatically adjusts the tire inflation system to reduce soil compaction, thereby increasing yield potential.
- Smart spraying technologies are being developed, using sensing technology, cameras and responsive nozzles for precision crop protection. This technology makes it possible to identify and spray individual weeds instead of the whole field, reducing herbicide use by up to 70 percent.

While new technology may raise concerns about job displacement, historical evidence suggests that increased agricultural labour productivity leads to workers transitioning to other sectors, ultimately benefiting the economy. The fear that automation, which increases labour productivity, will necessarily make people unemployed on a large scale is not supported by historical reality, because automation in agriculture is part of the process of the structural transformation of societies.

Agricultural labour-saving machines have a huge effect as they free people, mainly women, to engage in the workforce and develop careers. The fourth agricultural revolution with AI, robotics and digital technology hugely increases productivity. It is important to make these technologies scale-neutral and accessible to farmers of all sizes. This is true when it comes to digitization of machines, because data collected can improve yields but also give a deeper understanding of the interaction between crops and fields.

In conclusion, agriculture intersects with many global challenges, from climate change to biodiversity loss and poverty. The agricultural sector is rising to these challenges with technological advancements that can be applied to existing machines instead of rendering them obsolete.

The changes we are witnessing and implementing are truly transformative; automation and autonomy can deliver profitability while contributing to a more sustainable planet for future generations.

1.9 Policies and regulations for sustainable agricultural mechanization and digitalization

Josse de Baerdemaeker
Emeritus Professor, KU Leuven, Belgium

The new data-rich mechanization and agriculture

A typical agrifood supply chain has several steps. It includes a farmers' activities in the field, intermediate storage or silos, transportation from storage to processing plants, packaging, distribution and marketing to clients and consumers, and finally disposal. The low productivity of subsistence farming first increased with the use of animal power and early tillage tools. Next, the use of tractors and machines for seed bed preparation, fertilizer application and other tasks led to a large increase in agricultural productivity, referred to as Agriculture 2.0. Next, electronic tools such as sensors, cameras, computers and the Global Positioning System (GPS) were incorporated into agricultural machines, giving them the ability to electronically observe crops and harvests, and to measure, control, register and evaluate their quality and quantity while carrying out tasks with high precision. These precision agriculture tools allow for more efficient use of crop production inputs. Registered data are used for downstream process management and control. Data-rich mechanization plays an increasing role in agriculture. Combining data collected from many farms can help farmers plan their future crops for efficient productivity using available resources. Crop-production data linked with databases from downstream activities, processing, packaging and storage allows for economic optimization, market control, traceability, evaluation of alternate processes and for expanded applied research possibilities (Agriculture 4.0 leading to Agriculture 5.0).

Future challenges

Adopting technologies from different industries increases the speed at which agricultural equipment changes. These technologies offer creative solutions to improve productivity but could also have disruptive effects such as on the direct link between farmers and consumers. Innovations are not exclusive to large companies; medium and small companies, and even individuals, can also provide new developments as the globalization of the technological revolution lowers barriers to innovate. Automatic positioning via GPS, robotics, automation and data integration offer unexpected possibilities that we did not have before, and replace more traditional production methods.

While developments are exciting and challenging, several questions must be raised:

- Will farmers everywhere in the world have access to this new data-rich agricultural mechanization?
- Will local, national and global technology suppliers offer implements in a brand-neutral way, allowing cross-compatibility, with good aftersales services? Will they use or contribute to internationally recognized electronic, mechanical and safety standards such as ISOBUS?
- Will training and advisory entities be ready to support farmers in using innovative equipment?
- Will agricultural engineers be trained to adapt new technologies to agriculture rather than let things happen by chance? Will upgrades of study curricula be prepared?
- Will governments support the introduction of innovative equipment with the provision of an appropriate institutional infrastructure? Will they stimulate further technological developments while also stimulating the preservation of natural resources?
- Will innovations help farmers and governments cope with the uncertainties that come with climate change and changing cropping systems?

The adoption of innovation

The speed with which technologies and machines are adopted in the agrifood chain varies between regions and farm types.

For the past 60 years, installed machine power per unit of agricultural land was at a consistently high level for high-income countries, increased exponentially and reached a plateau in middle-income countries, while it stayed very low in sub-Saharan Africa.

Interestingly, in the last 30 years, ownership of mobile phones grew exponentially and reached a plateau in an equal way in all regions of the world. New and disruptive technology can be adopted at a high rate when it is promoted by technology providers, financial institutions and governments, and when it brings useful and easy-to-use applications for everyone. It must be a goal to make this happen for agricultural mechanization.

Farmers want access to machinery because it saves labour, allows more timely operations, increases productivity and potentially increases the land area or intensive production capacity. It can allow farmers to monitor and control irrigation systems or to start protected cultivation of high-value crops. However, a small family farm can only afford the ownership of light or animal-powered machinery. Through joint ownership or by renting with other farms, medium-sized machinery, such as two-wheel tractors or cultivators, come within reach. Larger farmers or independent business owners can be service providers for small farms seeking the advantages of mechanization through the economies of hired equipment and operators.

Entrepreneurs as forward drivers

Offering mechanization services to farmers can be a good business opportunity for entrepreneurs who assume financial debt for acquiring machines and collect a rental fee from farmers to pay for the cost of the loan. Entrepreneurs build on their own field experience, and integrate disruptive digital technology, such as GPS to know the location and condition of their machines, and mobile phones to allow farmers to book machines and operators, and to pay by phone. Services can include no-till planting, land-cultivation machines and harvesters, setting the scene for the next generation of precision agriculture, as service providers introduce innovation and modifications to machinery design based on their own field experience.

Farmers, advisors and technology providers, aware of the diverse range of technologies across industries that can make very positive contributions to the agrifood sector, are encouraged to rethink agriculture and food production. Technology that is available across the range of industrial processes, the electronic and medical world, the special world of data analysis and the massive amounts of data that are being generated in all economic sectors can be used to transform agrifood systems.

New policies for new technologies

Governments can guide the evolution of mechanization through various policies, strategies and actions, including to encourage cooperation between farmers, technology providers and governments. Existing policies and programmes should be audited or reviewed to determine if they are not detrimental to creating an enabling environment to foster sustainable agricultural mechanization.

Financial tools

Supporting sustainable mechanization requires, for example, (1) granting financial incentives to start-ups, including workforce training, engineering and repair, and maintenance support, (2) facilitating bank loans to mechanization service entrepreneurs and issue loan guarantees, (3) reducing the import taxes on agricultural machines or components to stimulate new mechanization for crop production, (4) allocating equipment taxes to fund the development of local agrifood equipment or innovations, and (5) using differential import taxes as incentives for stimulation of better local technology and equipment production.

Education, training and advisory assistance

When farmers realize that farm-machinery personnel are well trained, they will gain more self-assurance in the farm-mechanization process. Options to increase farmers' and institutional capacities to support sustainable agriculture mechanization include, for example, (1) installing training facilities to improve the digital literacy of the farming community both directly and through rural extension services, (2) stimulating the creation of multidisciplinary technology centres that also are responsible for forward-looking assessment to manage advances in agrifood technology, (3) offering specialized technology advisory services for farmers with clearly defined tasks and goals, and (4) reviewing and updating curricula at secondary and higher-education institutions to prepare and motivate young people for careers in technology and mechanization in agriculture.

Grow new technology leaders

In today's rapidly evolving agricultural-mechanization landscape, technology leadership is a pivotal factor in driving adoption of innovations. The creation of a special research fund, or specific competitive calls for research proposals, can target national or subnational needs for sustainable agricultural mechanization. Example topics for such calls can include mechanization and equipment that contain new technologies for conservation agriculture with special attention to small farmers. The creation of unbiased testing and experimentation facilities can facilitate start-up companies to work with engineering experts and crop specialists on new designs and concepts for agrifood technology appropriate to local circumstances, keeping in mind the entire agrifood value chain. In-company training and education for young engineers in preparation of their leadership role in data-rich agricultural mechanization can be offered, keeping in mind the need for equal opportunities for women.

Concluding remarks

The development and deployment of digital agricultural mechanization around the world is a formidable task that requires excellence in mechanical engineering, electronics, data collection and analysis, economics, and protection of natural resources. Rather than watching this evolve slowly, governments and the agricultural community should adopt a forward-looking strategy that, while incentivizing existing technology providers, puts a new breed of entrepreneurs in charge of integrating and adopting new technology in agriculture and food mechanization.

The ability to harness the power of technology and engineering to solve social problems, as well as food problems, must be accompanied by complementary adaptations in social agriculture institutions. Governments and the agriculture sector must show leadership and adopt forward-looking strategies to develop new agriculture-oriented technologies that meet local needs. Policies are needed to assess and incentivize existing technologies, enable institutions and programmes to connect agriculture with technology and mechanization, and encourage young people to choose career paths and aspire for leadership in the sustainable-agricultural-mechanization value chain. Modern agricultural technology must be attractive to young people, not only in the form of mechanization, such as tractors or improved post-harvest management techniques, but also to develop career paths based on the use of information and communication technology, with better access to information about services and markets.

Everyone here at the conference has a role to play in increasing the development of sustainable agricultural mechanization. The roles may be diverse, but collaboration and cooperation are necessary. Planning for the future can start here and start now!

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Chapter 2

Mechanization for crop production

Parallel session: Efficiency and productivity

2.1 Sustainable agricultural mechanization and crop production – exploration and practice of an unstaffed farm

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Mechanized crop production and smart agriculture are the future of modern farming. Unstaffed farms are an important element in achieving these goals. In 1996, the South China Agricultural University (SCAU) developed equipment to measure soil tillage resistance that incorporated GNSS. The equipment can measure the resistance of soil to tillage on large areas and at different depths. From 2003 onwards, SCAU carried out research on agricultural machinery navigation technology. Another significant milestone was achieved in 2006 with the successful development of China's first autonomous rice transplanter. And in 2020, SCAU successfully developed the first unstaffed rice farm in the world.

On the unstaffed farm, the following tasks are performed autonomously: (1) all production processes, including tillage, planting, management and harvesting;
(2) moving between the garage and the field;
(3) detecting and avoiding obstacles, and stopping in response to an emergency; (4) monitoring the entire production process in real time; (5) taking decisions and carrying out precision operations in a data-driven manner. The unstaffed farm is made possible by four technological advances, namely digital information perception, intelligent decision making, precision operation and intelligent management.

In 2021, the yield for early-season rice on the unstaffed farm was 9.9 tonnes per hectare, surpassing the regional average yield of 7.5 tonnes per hectare. By the end of 2022, 30 unstaffed farms were established across 15 provinces in China for the cultivation of rice, wheat, maize and peanut. This expansion highlights the immense potential of unstaffed farms to contribute to modern agriculture.

Unstaffed farms significantly contribute to the efficiency, inclusiveness and resilience of sustainable agricultural development. In the future, more unstaffed farms will be established to optimize mechanized crop production systems.

2.2 Smallholder agricultural mechanization in developing countries – bridging the agricultural gap

Stanley Silwimba
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To reduce labour requirements and expand areas under cultivation by smallholder farmers practising conservation agriculture in Zambia, the Conservation Farming Unit designed and implemented a private-sector lend–lease scheme to make mechanized tillage and transport services available to small- and medium-scale farmers. This was carried out despite the widespread belief that small-scale farmers cannot mechanize because they lack the capacity to borrow from and repay commercial markets and they lack collateral to secure loans.

This presentation highlights the design, partnerships, implementation and lessons learned from a carefully considered lease finance scheme, which involved the following partners: First National Bank (financier), AFGRI and SAROAGRO (equipment suppliers), Conservation Farming Unit (beneficiary selection, technical trainer and loan guarantor), John Deere International (co-guarantor and equipment manufacturer), Lloyds Financials (credit guarantee fund manager), Musika (farmer business training) and insurance companies.

In the first year of its implementation, 11 out of 4 367 applicants were granted access to the facility, demonstrating the rigour of the selection process. The number grew to a total of 619 selected farmers. The selected farmers benefited from a loan with repayment over three years, and a package composed of a tractor with accompanying minimum tillage rippers and/or no-till planters and trailers, equipment maintenance by the suppliers and insurance of the equipment. Of the 619 loan beneficiaries, only three defaulted (a 0.48 percent default rate). The banks incurred no losses and no funds from the Credit Guarantee Fund were used because of the 20 percent down payment, the monthly instalments paid from proceeds of the tillage-service provision to other farmers and the recovery and sale of the equipment.

Opportunities for mechanization in the small- and medium-scale sector in Zambia are enormous, but we must learn from the mistakes of the past, progress cautiously, apply common sense and insist on the application of sound business principles.

Schemes should be based on sound business principles and accompanied by:

1. careful and thorough screening of potential loan recipients;
2. effective practical and business training;
3. equipment packages tailored to small- and medium-scale service provision;
4. timely delivery of new equipment; and
5. back-up services for maintenance and spares.

Although the scheme was successful, it was not without problems. The challenges were of both technical and socioeconomic in nature, with equipment intended to increase crop productivity sometimes being diverted to more “lucrative” ventures.

2.3 Empowering women and marginalized groups through agricultural mechanization

Eva Marina Valencia Leñero
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So far, women and marginalized groups have not been part of the mechanization supply chain, nor have they benefitted from agricultural innovations. Enabling conditions and structures supporting women and marginalized groups to use machines and benefit from sustainable mechanization innovations are still insufficiently developed.

These groups also need access to financing and business models to scale up mechanization innovations. Political support for all the above is also needed. This was evidenced during our Scaling Scan assessment in a project to scale up mechanization in Africa and Asia, in collaboration with FAO and GIZ.

According to the Independent Science for Development Council of the CGIAR, inclusive innovation is based on "means by which new goods and services are developed for and/or by those who have been excluded from the development mainstream", for example, groups characterized by gender, age, ethnicity and geography. In this definition, we find two main requirements for any agricultural innovation to be inclusive: (1) the innovation must be a means to an end, and (2) it must be created for and/or by excluded groups.

First, mechanization solutions should be context and scale-appropriate, as CIMMYT has learned in different projects around the world. For example, instead of oversized four-wheel tractors, a scalable machine that can manage the amount of seed and fertilizers to be planted by hand was introduced in small agricultural areas in Latin America. This initiative saved days for small-scale farmers and gave them time for other employment opportunities and family caretaking.

Second, marginalized groups, as end users, should initiate the demand for machinery and should co-create and participate in the creation of the supply (as engineers/builders of the machines).

From the consumption side of mechanization innovation, machines need to be adapted to *respond to the agricultural challenges of marginalized groups*. User-centred design can, for example, lead to adapting the size and shape of machinery. Another way could be to develop machinery for other tasks in the field, where marginalized groups have a more prominent role. For example, in Côte d'Ivoire, a consortium of partners formed by CIMMYT, FAO and GIZ, supported women responsible for processing cassava by scaling a cassava presser and grinder, which decreased the effort and increased the processing by 1 000 percent. The device was also made available to other communities in the area through a renting scheme.

2.4 Mechanization at the service of new environmentally friendly practices

Peter Groot Koerkamp
Professor in Biosystems Engineering / Agrotechnology and managing chair of the Farm Technology Group of Wageningen University, Kingdom of the Netherlands

Crop production around the world faces a range of challenges. Maintaining and improving yields and product quality appears to be at odds with sustaining the environment, human health and the economy, as measured by respective performance indicators.

This presentation focuses generally on the challenges for soil quality and soil health, and particularly on how to avoid soil compaction in (highly) mechanized farming systems.

Soil compaction can be a serious limiting factor for plant growth and soil life, and therefore for soil quality. In the many developments in the field of precision agriculture and robotics to contribute to more sustainable crop production, not enough attention is paid to soil compaction.

The size and weight of machines continue to increase, and full controlled traffic farming from planting and seeding to harvest is not easy to implement. In addition, new cropping systems such as (strip) intercropping pose new challenges for machines.

More attention is needed for the transport of goods (planting material, water, harvested product) and machines on the field, along with novel design concepts for machines and field operations.

Parallel session: Innovative technologies

2.5 Alternative power/fuel sources combined with automated solutions

Gilles Mayer
Head of Global Tractor Product Management for Alternative Fuels, New Holland/CNH-Industrial

Despite numerous challenges, farmers have successfully maintained the resilience and security of the food supply chain in the European Union in recent years. Taking these developments into account, agricultural-industry actors have a responsibility to develop new technology and equipment that allow farmers to produce more food from less land, with declining resources and at higher costs.

Sustainability, innovation and productivity are the core of the strategy and company purpose of CNH Industrial. Its sustainability strategy is centred around four areas linked to six of the United Nations SDGs. CNH Industrial has a long history of researching and promoting the position of agricultural mechanization within a sustainable future for agriculture, based on precision farming, equipment and training that supports sustainable farming practices and alternative energy sources. The New Holland Agriculture biomethane tractor marks a significant milestone in the journey towards decarbonizing agriculture. It is the result of years of pioneering work on the use of alternative fuels, and it represents a unique opportunity to speed up the deployment of energy-independent farms.

As well as investing in great technology, CNH Industrial is also keen to encourage more young people to see opportunities for productive and exciting professional careers in the agricultural sector. To this end, we invest heavily in training programmes to facilitate the introduction of innovative solutions for our dealers and customers.

2.6 Innovations in precision planting: the role of seed pelleting

Christine Hazel
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The impact on the agricultural sector of using advanced seed-treatment technology, such as pelleted seed, is significant. Pelleted seed are coated with a mixture of clay and water or fibre and binders, resulting in a smooth, round and uniform shape that can increase seed weight by over 500%. They are designed to promote sustainable agriculture and benefit farmers, the environment and the overall economy.

One of the main advantages of pelleted seed is their larger and more uniform size, which facilitates their handling and allows the use of mechanized and pneumatic seeders. This planting method results in higher planting speed, fewer doubles or empty seeding spaces in the field, and reduced need for thinning, saving both seed and labour costs and increasing productivity. Increasing seed size through pelleting reduces waste of currently unsellable, small-sized seed, improving profitability.

The use of pelleting technology is an effective way to improve the health, vigour and yield potential of a crop, allowing farmers to fully maximize their crop potential.

Seed pelleting also offers the possibility to apply an additional precise seed coating containing small amounts of crop-protection products, additives, nutrients and biological agents. This is a safe and efficient way of applying these products to the crops, as the ingredients remain on the seed, reducing the need for soil and foliar pesticide applications, benefiting both workers and the environment. This practice also results in healthier and more robust crops that are more resilient to pests and diseases, and produce higher yields and better-quality produce.

When combined with sustainable agricultural practices using cover crops and no-till practices, pelleted seed can improve crop emergence and crop vigour, thus facilitating adoption of these practices. It offers an economical and sustainable way to boost food security by maximizing crop yield potential.

In summary, pelleted seeds offer a wide range of benefits for sustainable agriculture. They are specifically designed to promote mechanized planting, improve plant production and benefit the environment. Pelleting technology is an effective way to promote efficient, safe and environmentally friendly crop production that is essential for ensuring food security.

2.7 Innovations in crop protection: precision application technologies for agrochemicals and options for mechanical weed control

Virender Kumar
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Rice – a staple food for more than half of the world's population – is crucial for global and regional food security. By 2050, an additional 75 million tonnes of milled rice will be needed to meet global rice demand and ensure food security, while using fewer resources such as land and water, using inputs such as labour and chemicals more efficiently, minimizing the impact on the environment, and adapting to climate variability. One way to achieve this goal is to reduce rice-yield gaps caused by weeds.

In Asia, manual weeding is the most common and traditional practice to control weeds, but labour scarcity and increasing wages make it less feasible and less attractive. Herbicide-based weed control is increasingly seen as an attractive alternative; it is effective and economical in controlling weeds and allows for lower labour costs. However, risks associated with herbicides include the development of herbicide resistance in weeds, negative effects on non-target organisms and soil biodiversity, and health risks to applicators due to direct exposure during spraying. New weed-management approaches that provide cost-effective weed control while minimizing negative impacts on the environment and human health are needed.

The use of motorized weeders, alone or in combination with herbicides, and the application of herbicides with drones are being tested in India and the Philippines with encouraging results. Combinations using single-row and double-row motorized weeders, hand-weeding and a limited application of herbicides result in yields comparable to those resulting from fully herbicide-based treatments. In farmer fields, integrated treatments also give significantly higher yields compared to farms practicing manual weeding.

Experimental application of herbicides by drones shows that drone-based herbicide application can provide the same efficiency as manual application but without human exposure, at a much faster speed, and with ultra-low water volume. The implications of drone-based applications on reduced water volume, the determination of drone speed and flying height, and the types of herbicides for weed control are being investigated.

Results show that motorized weeding alone or in combination with herbicides can provide effective weed control and reduce herbicide application. Moreover, drone-based herbicide application could be a game changer in tropical Asia in reducing human exposure to toxic chemicals without compromising weed control efficacy and for site-specific precision application in the future.

2.8 Innovations in protected cultivation: automation and robotics for crop production

Naoshi Kondo
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The world's population has steadily increased to nine billion, creating a global trade-off problem of food production versus environmental conservation that must be resolved at national levels. Two ways to contribute to the solution can be highlighted: the first is to increase the productivity of agricultural products in open fields with a minimum impact on the environment. The other is to reduce food loss and waste in the post-harvest and consumption stages.

Since the 1980s, there has been a sharp increase in the use of highly automated and robotized systems to increase agricultural productivity. They are based on the use of machines with sensor technologies such as seeding and transplanting robots, grading robots, UAVs and, more recently, robot tractors. Imaging technologies of crops and agricultural products are added to obtain more information about the external condition of crops, such as colour, size, shape, disease and injuries. In addition, machine-learning technology (artificial intelligence) has gained momentum by using imaging in agricultural fields to monitor agricultural products and control machines.

In post-harvest grading and sorting facilities, imaging sensors were installed in the 1990s and are effectively deployed using fluorescence to predict and circumvent potential sources of downstream fruit loss. For example, very minor injuries, not detectable to the naked human eye, that have the potential to rot or become infected with bacteria or fungus and infect healthy fruit after leaving the packhouse can be detected with fluorescence imaging technology developed 15 years ago. Fruit with minor damage, even pinholes, can be separated from healthy fruit, thereby reducing the risk of fruit loss further down the value chain and increasing the volume of healthy fruit reaching consumers.

Crops and agricultural products contain fluorescent substances, such as chlorophylls, proteins, amino acids, vitamins and organic compounds. When activated, measured emissions can reveal information that can help detect very minor damage that can lead to significant downstream losses, authenticate product quality, identify foreign biological objects, distinguish between desirable and unwanted products, determine the level of maturity or freshness of the produce, detect the presence of chemical residues and identify fruit rot that is difficult to detect. It is easy to predict this technology will increasingly spread to open-field crop monitoring, using UAVs and other imaging systems for early detection of disease and insect damage. As a result, reduced food loss and reduced use of chemicals can be expected.

To use fluorescence technology on food and agricultural products and design the fluorescence spectroscopic and imaging devices, information on the activation, emission and time series intensity of wavelengths for fluorescence substances should be known. A database for pure fluorescent compounds exists, but the natural fluorescent compounds in agricultural and food products can vary with time and environmental conditions, and undergo changes during handling, storage and processing. This calls for the creation of a new database, specifically for agriculture. Fluorescence sensing is a technology that is usable not only for large-scale agriculture but for small-scale agriculture and even for home refrigerators, and thus is a promising technology for the future.

Chapter 3
Post-harvest and agroprocessing

Parallel session: Harvest and post-harvest

3.1 Integrated approach for a better harvest and post-harvest management and technologies

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Whereas the pre-harvest history of a crop (e.g. crop variety, growing and management conditions) determines the initial quality of the produce that will be further subjected to different post-harvest handling operations, integration of post-harvest management strategies is key to ensuring global produce quality from harvest to retail. This involves a clear, consumer-perspective definition of the product's quality and value.

Harvesting at the appropriate stage of maturity, in the right conditions and at the right time minimizes the impact on product quality and its potential shelf-life (e.g. by minimizing mechanical damage, dehydration and time between harvest and cooling). At the harvest stage, sustainable mechanization considers the different levels of food-system development and plays a pivotal role in optimizing efficiency and yield while reducing occupational injuries and musculoskeletal disorders. Determining the optimal harvest timing is based on harvest indices that can be measured by destructive and non-destructive methods. Destructive methods involve sampling and analysing crops at various stages to determine their maturity, allowing for accurate evaluation but resulting in losses for sampling purposes. Non-destructive methods involve technologies such as spectrometry, spectroscopy and hyperspectral imaging to assess parameters such as colour, texture and chemical composition. Non-destructive methods with handheld instruments used on farms enable real-time monitoring, reducing waste, enhancing accuracy in determining harvest readiness, and thus contribute to improving food security.

Harvesting fruit and vegetables is labour intensive. Mechanical-harvest technologies (such as "shake and catch", "harvest-assist platforms" and robots) have generated a degree of interest, but widespread adoption by farmers is limited due to doubts about the reliability and robustness of the technology and on the economic benefits. Small-scale growers might me more inclined to adopt technologies, such as harvest-assist platforms, if additional functions were incorporated (e.g. sorting). Modern food systems are implementing harvesting robots that include two main components: a vision system that identifies target fruit or vegetable, and a system to detach or harvest it.

Post-harvest handling activities on modern food systems also include automated sorting and grading systems equipped with advanced sensors and machine-vision technology that enables the rapid and accurate identification of defects, sizes and quality parameters in packing lines. AI is used in image-capture techniques for further processing and in the development of inspection applications. Storage and transportation are also integral aspects of post-harvest management. Sustainable mechanization introduces energy-efficient cooling and storage systems that maintain the optimal temperature, humidity and gas composition for different produce. This extends shelf-life and reduces spoilage, contributing to food security. The use of sensors (e.g. temperature, relative humidity, atmosphere composition, ethylene, etc.) in combination with the internet of things and data technologies allows products to be monitored in real time during storage and transportation, and allows decisions to be made on handling priorities.

3.2 Innovations and advanced technologies to reduce post-harvest losses and increase income

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Approximately 30 percent of fresh fruits and vegetables is lost during post-harvest. Effective post-harvest management is crucial to minimize food waste, bolster food security and optimize resource utilization. There is growing interest in creating and implementing innovative technologies aimed at prolonging the post-harvest lifespan of fruit and vegetables. A diverse array of pioneering approaches with great potential in preserving the freshness, nutritional value and marketability of these perishable products exists.

The timing of fruit and vegetable harvesting is a critical factor. If harvested prematurely, they may be unripe; if harvested too late, rapid deterioration may occur. Climacteric fruit possess a unique characteristic: they can be harvested when immature, stored in a low metabolic state for some time and triggered to ripen by ethylene (a volatile plant hormone). Still, determining the optimal harvest time for this type of fruit is equally crucial. Recent developments make use of portable spectral sensors and cloud-based services for non-destructive determination of the ideal harvest date, based on a set of maturity indicators.

Maintaining low temperatures during storage is essential for prolonging the storage life of fresh fruit and vegetables. Furthermore, adjusting the oxygen and carbon dioxide levels in the storage atmosphere can reduce a product's respiration rate, further extending its storage life. Controlled-atmosphere storage is a known technique, but a new advance is dynamic controlled-atmosphere storage, which continuously measures the fruit's physiological condition and adapts oxygen levels in real time. Another exciting development involves the integration of smart sensors and IOT devices for real-time monitoring of temperature, humidity, gas composition and other essential variables, enabling immediate adjustments and interventions. These variables can also be input into predictive models, facilitating data-driven decision-making through machine learning algorithms, ensuring optimal storage conditions, and extending produce shelf life. Additionally, renewable-energy solutions are being incorporated into post-harvest storage operations. Solar-powered cold storage units, for instance, offer a sustainable and cost-effective means of preserving crops in off-grid areas, revolutionizing regions with limited access to reliable electricity.

Innovative coatings and packaging materials are being developed to extend the storage and shelf life of fresh fruit and vegetables. Smart packaging materials integrate sensors, indicators and modified atmosphere technology to actively manage the conditions within the package. Within these packages, there are ethylene-absorbing and antimicrobial films that further suppress spoilage and microbial growth.

AI and machine learning have led to a revolution in post-harvest sorting and grading processes. Advanced computer vision systems can analyse the quality of each individual fruit or vegetable, sorting them based on size, colour and defects. This increases efficiency and reduces waste by ensuring that only high-quality products reach the consumer. In combination with appropriate traceability technologies, information obtained during sorting and grading can be correlated with pre-harvest factors to improve cultivation procedures.

Novel post-harvest technologies reshape the way we handle and preserve fresh fruit and vegetables. These innovations boost efficiency, reduce waste and ensure that fresh, nutritious produce reaches consumers worldwide.

3.3 Drying and storage technologies for grains

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China is the world's largest producer and consumer of cereals, with the annual planting area of major cereals such as rice, wheat and maize exceeding 100 million hectares and the total production exceeding 630 million tonnes (National Bureau of Statistics, 2022). The area under small-scale farming accounts for 71 percent of the total planted area in the country. However, up to 35 million tonnes of cereals are lost per year due to inadequate drying, transportation and storage (National Food and Strategic Reserves Administration, 2021). Out of these, losses from storage at small-scale household level accounts for 20 million tonnes. Drying and storage are critical stages in the production cycle of cereals.

In 2021, China's total drying capacity was only able to dry 26.7 percent of the country's annual rice production. The development of mechanized grain drying in China shows a significant imbalance between the north and the south of the country, with greater mechanization in the south. For example, batch-type low-temperature circulating dryers are primarily used for drying rice and wheat in the southern regions of China. In the northern regions, large-scale continuous drying towers are mainly used for drying wheat and maize. China has a combination of centralized State storage and decentralized household storage for grain. Small farmers and new types of agricultural entities store approximately 40 to 50 percent of the total annual production. However, their storage facilities are crude, and the grain-storage technology is outdated, resulting in significant losses due to rodents, mould and pest damage.

Most regions are increasingly opting to invest in building regional drying and storage centres and offering paid drying services to the surrounding farmers to increase the utilization rate of dryers. China also uses fiscal subsidies to promote the construction of regional drying centres and the use of green and clean energy. Farmers who purchase machines can benefit from financial subsidies based on the loading capacity of the dryer and the maximum heating capacity of the green heat source. Despite this policy supporting the purchase of equipment through subsidies, the willingness of farmers to purchase is low due to the high price and single function of the grain dryer, resulting in grain dryers ranking tenth in terms of sales among agricultural machinery. The development of energy-saving, efficient equipment integrating green technology is needed.

High equipment prices and usage costs are the main challenges for the development of grain-drying mechanization in China. Both technological upgrading and policy support are needed. From a technical perspective, inefficient hot-air stoves and drying processes lead to high energy-usage costs. In terms of drying patterns and policy support, we need to address the problems associated with high equipment-purchase costs, the single function of dryers and farmer reluctance to use them. Another area requiring attention is the development of small mobile dryers to provide convenient drying services for small-scale farmers.

The development of grain-drying and storage equipment, and reducing post-harvest losses for cereals, is critical to guarantee global food security. It requires joint efforts from various fields, such as technological improvements, policy support and model innovation.

3.4 Importance of washing, hygiene, drying, precooling and correct packaging for better operational and supply-chain management

John Christopher Duffill
CEO, John Crop Development International and John Crop Development Viet Nam

It is important to understand the process flow and the importance of hygiene, washing and drying, precooling and packaging to improve the operation and supply chain of agricultural products. Personal and environmental hygiene profoundly affect a product's final quality. This can affect purely quality-based parameters but also by cause microbiological or fungal wastage, which not only is costly but could lead to legislative issues for food safety.

Hygiene is often overlooked in a primary processing packing facility. However:

- personal hygiene is a crucial first step to ensure that products meet customer demands and legislative quality and hygiene requirements;
- environmental monitoring should be set up for all aspects of the business and allow for appropriate trend analysis to pinpoint any changes to a business' general standards;
- washrooms need to have cleaning schedules with separate equipment; and
- cold storage needs regular maintenance, cleaning and monitoring procedures.

Washing is a crucial step in the process.

- Only potable water or water that has been treated and classified as potable can be used.
- Washing additives must be food-grade and suitable.

- It is essential to consider the physiochemical and microbiological characteristics of the water.
- Different approaches exist to control water quality (e.g. ozonation, chlorination, Ph adjustment for chlorine).
- Automated systems incorporating data logging are preferred.

Drying

- It is essential to look at different, suitable drying processes, including ultra-violet sterilization, adapted to the product type.

Precooling

- Precooling is dependent on the type of product.
- It is generally good practice to reduce the product temperature at each processing stage until the final pack.
- Packing the product at shipping temperature provides more efficiency to the cool-chain process and reduces the risk of premature product deterioration.
- This requires availability of a chilled packing environment after precooling.
- Regular maintenance is fundamental for the cleanliness and efficiency of the system.

Packaging must be:

- designed specifically for the product;
- designed with correct ventilation for airflow and be of sufficient strength for palletization and correct shipping;
- designed with post-harvest quarantine requirements in mind;
- fully food-graded with food-grade inks and materials; and
- certified and audited.

Transport cleanliness should never be overlooked as an essential part of the chain.

- Check drain holes, refrigerator units, integrity of the floors.
- Check product temperature on loading and ensure the cooling unit is operational before departure.

In summary, most practices identified here are basic common-sense items, and help ensure that clients benefit from reliable and sustainable source products, better quality and an extended shelf life. It is not one specific action, but a combination of a multitude of small steps that add up to the end goal.

Parallel session: Resilient cropping systems

3.5 Agroprocessing global perspective – drivers and triggers for transformation

Umezuruike Linus Oparal

Chair, DSI-NRF SARChI Postharvest Technology; Director, Africa Institute for Postharvest Technology

Global agriculture and food systems are at a critical juncture due to a wide range of factors. On the one hand, globally, food production has increased during the past decade, though it has not kept pace with population growth, particularly in developing and emerging countries. On the other hand, several global challenges, especially climate change and global warming, biodiversity loss and environmental degradation present new obstacles to agrifood systems to meet the demands of a growing population. Concomitantly, post-harvest losses and food waste remain high, contributing to increased food and nutrition insecurity. Addressing these challenges requires a new thinking about how we produce, handle, process and deliver quality food that is nutritious and safe to consumers.

Historically, agroprocessing enables farmers to transform and save their harvest for future consumption and to

3.6 Protein transition food (examples from Kenya and Mexico)

Dorte Verner
Lead Agriculture Economist, World Bank

market diverse fresh and processed products off-season. Agroprocessing allows post-harvest losses and food waste to be reduced, raw agricultural food materials to be transformed into various value-added products, contributes to food and nutrition security and promotes trade through the development of new agricultural value chains.

The status of agroprocessing is a major indicator of the status of agricultural development and modernization. Several factors contribute to the successful development of agroprocessing at small-, medium- and large-scale agribusiness levels. These include knowledge and technical expertise and skills on optimal processing techniques and procedures, availability and access to relevant machinery and equipment, infrastructure (such as energy and water supply), packaging and storage technologies, logistics and distribution, and access to trade, markets and finance. The importance of education, research and innovation in developing a sustainable agroprocessing industry cannot be overemphasized. To access and retain markets, agroprocessed products must meet consumer demands for reliable supply, quality, safety and affordability. Improved technologies, including new equipment and energy technologies, are necessary to process raw agromaterials and to maintain quality and product safety. To achieve and maintain production targets, the agroprocessor requires a reliable supply of quality raw materials. The cost of production must also enable the agroprocessor to be profitable and competitive alongside similar and alternative local and imported products.

Over time, agroprocessing has emerged as a critical part of the manufacturing industry and food systems in developed economies, as showcased by a few very large scale agroprocessors dominating global markets. In developing regions, in particular sub-Saharan Africa, imported processed food alongside minimally processed local food products dominate local markets. Agroprocessing remains largely rural, subsistent and small-scale. Locally processed products hardly meet local demand, nor the high-quality standards needed to access regional and international markets. In many cases, the value chains of local food crops remain largely underdeveloped, limiting the diversity of locally processed food products in markets, especially in the rapidly emerging supermarkets and hypermarkets of Africa.

Mechanization, including modern and improved equipment and power supply, is an increasingly critical input for the development of a successful agroprocessing industry in sub-Saharan Africa, including for root and tuber crops. The role of research and innovation is critical.

The world's wide-ranging food security and food-system challenges require disruptive, inclusive and resilient solutions for transformation. Insect farming costs and benefits can be the base of a circular food economy, by unleashing investments to bring insect farming technologies to scale. They allow increased production of novel animal protein while turning organic waste from a liability into an asset, creating jobs and reducing greenhouse gas emissions.

Organic waste products from food and agriculture can be fed to micro livestock, and the outputs can be used for producing human food, animal feed and biofertilizers.

Insect farming is therefore an integral part of agroprocessing and of sustainable agricultural mechanization. The outputs of the process can, for example, include protein, oil and chitin. The emission of greenhouse gasses is reduced, and jobs are created along the value chain. This can be relevant for urban as well as rural locations, including arid areas without requiring mechanization, arable land or water. It is particularly relevant for increasing climate resilience for all, including people with little or no access to arable land and water, as well as for women and young people.

Insect farming produces nutritious human food and animal feed, and could provide tremendous health, social, economic, climatic, environmental and food-security benefits in many countries, including fragile and conflict-affected economies. Insect farming can create a circular food economy by reusing society's organic waste and turning it into valuable food for humans, pets, fish and livestock without the need for vast amounts of arable land or water resources. It is a viable complement to conventional agriculture and could meet many of the world's social, economic, environmental and food-security challenges. It is economically competitive and complements conventional agriculture in resource-constrained environments while generating only a fraction of the climate and environmental damage. This is an appropriate time for unleashing investments to bring the technologies to scale, including technologies involved in the transformation of insects into value-added products, technologies that can provide jobs and technologies that significantly reduce greenhouse gas emissions.

3.7 Agroprocessing business on cocoa for export (standards, traceability, financing, sourcing, quality control)

Patricia Poku-Diaby

Businesswoman, cocoa merchant, CEO of Plot Enterprise Ghana Limited

Ghana and Côte d'Ivoire combined have, for decades, been the source of about 70 percent of the world's cocoa bean production. However, for many historic and economic factors, both countries process less than 50 percent of the production, with local processors representing less than 5 percent.

In the Plot Group – Plot Enterprise Ltd in Ghana and Plot Enterprise SA in Cote d'Ivoire – and the affiliated sourcing companies, despite numerous challenges, we continue to strive to achieve our goals of adding value to cocoa beans in a sustainable environment in an industry dominated by multinationals.

The Plot Group looks at the cocoa processor's narrative, from the farmgate to the end user, with a key role for regulators, areas, sourcing, quality control, financing and market accessibility, and a focus on sustainability. Our monitoring of farming practices cuts across sensitive issues such as child labour, safeguarding the environment and ensuring that the raw material – the cocoa bean in these regions – is sourced, processed, harvested and transported in the most sustainable manner.

With the world leaning towards sustainable practices, standards are evolving and, to remain relevant in the international cocoa processing space, it is imperative to align with ever-changing expectations in the competitive cocoa environment.

The role of the regulator and other agencies in cocoa operations is key to the survival of the industry. The services provided by the regulator and other agencies have an effect across the cocoa-processing chain.

Many factors within the cocoa-processing space serve as a strong deterrent to a would-be local processor. The most critical include the capital-intensive nature of cocoa processing, price volatility and the pricing of cocoa bean on the international market. Other specific factors such as the cost and reliability of energy, financing costs and climate change also affect the production and quality of beans in our region.

The challenges notwithstanding, the Plot Group remains resolute in its mission to add value to cocoa's raw materials instead of simply exporting the raw beans, by manufacturing cocoa products of the highest quality made from cocoa beans produced in Ghana and Côte d'Ivoire.

The Plot Group is committed to maintaining strict adherence to legal requirements, ethical principles and global standards.

3.8 Waste valorization for added-value food products (use of bioproducts, environmental perspectives, efficiency)

Quan Vuong
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Roughly a third of the world's food, around 930 million tonnes, is wasted globally each year, which results in economic losses and has a significant impact on the environment.

While reducing food waste has social, economic and environmental benefits, it is challenging due to the involvement of numerous parties and the various and complex sources of waste that occur at every point along the supply and consumption chain.

It is important to note that food waste is susceptible to degradation, and the valorization of food waste involves multiple steps. Therefore, identifying cost-effective conditions for each step is crucial to successfully transform food waste into value-added products.

Our studies on organic agricultural waste have revealed that this can be reduced through the valorization into value-added products. For example, coffee pulp generated from coffee bean processing can be used to produce a powdered extract with high phenolic content levels, which is suitable for various applications. Citrus pomace, derived from the industrial processing of juice and essential oils, can serve as a functional ingredient when combined with manuka honey and Leptospermum extract to produce a healthy product with, allegedly, potential anticancer properties. Soy okara, a by-product of the soy milk and tofu production process, is made of the insoluble parts of the soybean. It is a versatile ingredient that can be used in a variety of dishes. It can replace wheat flour to create bread with high dietary fibre, and other baked goods.

Chapter 4
Climate change and resilience

Parallel session: Conservation agriculture

4.1 Adopting conservation agriculture: facing the challenges and grasping the opportunities for sustainable agriculture

Marie Bartz
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The soil provides a series of ecosystem services that guarantee and promote life in the terrestrial environment. Considered by many to be a renewable resource, the capacity for soil formation and renewal is slow. Depending on climatic conditions, it can take between 500 to 1 000 years to form just one centimetre of topsoil. Human action has deteriorated and degraded soil through deforestation, agricultural activities, overgrazing and poor soil use and management, resulting in severe water and wind erosion. It is a process that has been going on since the oldest civilizations until the present day, and now makes agricultural production impossible on 30 percent of the world's soil.

Estimates report that, without changes, by 2050, 90 percent of the world's soil will be unsuitable for food production. In this sense, with the aim of regenerating, caring for, protecting and conserving our soils, for more than 50 years, regions around the world have been adopting the concept of conservation agriculture applying three basic rules: (1) minimum mechanical soil disturbance; (2) permanent soil cover with crops, crop residues, mulch or cover crops; and (3) crop diversification involving rotations or associations, including cover crops. By adopting these principles, the soil system, in the medium to long term, becomes healthier and more resilient, which is directly related to the return of life (biological activity) to the soil. Soil biodiversity is the driving force that governs the chemical (nutrient cycling, accumulation of organic matter and consequent carbon sequestration) and physical (structuring, increasing infiltration capacity and water storage) processes in the soil. The resulting provision of important ecosystem services has repercussions on the productivity and costs of agricultural production.

Soil organisms form a chain reaction of processes and interactions, known as the soil food web. Plants provide the initial source of the food web, which is carbon. To keep the chain functioning, its living components must have protection (soil cover), a home (non-mobilization) and abundant food in quantity and quality (crop rotation and diversification). Conventional soil-management practices (ploughing, harrowing and subsoiling) and the excessive use of inputs (fertilizers and pesticides) directly affect the survival and development of life in the soil. Pulverized soils are exposed to the elements that liquidate and sterilize them, leading to their degradation and loss of productive capacity.

Conservation agriculture is the best way to maintain soil health and environmental resilience, allowing soils to better withstand extreme weather conditions or events, and ensure that soils can maintain productivity.

Promotion of soil health triggers another chain reaction: healthy soils produce healthy plants, which leads to the production of healthy food and consequently healthy human consumers. However, globally we still only have 14.7 percent of agricultural land under conservation agriculture. The expansion of this way of caring for the soil should increase to guarantee global food production and human survival.

4.2 Small-scale mechanization for conservation agriculture

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Cropping Systems Agronomist, International Maize and Wheat Improvement Center (CIMMYT), Dhaka, Bangladesh
Huibin Zhu
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Food and nutrition security and the livelihoods of smallholder farmers in Bangladesh, China and India largely depend on agriculture. They typically manage farms smaller than a hectare. For mechanization, they depend on small, four-wheel (30 hp –70 hp) and two-wheel agricultural machines. In Bangladesh, land preparation, irrigation, agrochemical spraying, threshing and dehusking of rice and pulses are more than 95 percent mechanized.

In India, land preparation is 70 percent mechanized, whereas seeding and transplanting, intercultural and plant protection, and harvesting and threshing are mechanized for approximately one third of farmers. Operations for seeding, transplanting, weeding, harvesting and drying have limited mechanization rates (less than 10 percent).

In China, mechanization rates for land preparation and irrigation are high (85 percent and 77 percent respectively). Operations for seeding, transplanting, chemical spraying and harvesting are more than 50 percent mechanized, while drying is less mechanized (25 percent).

Worldwide, conservation agriculture covers about 200 million ha, with proven sustainability benefits for dryland crop production. Research and development in conservative agriculture have been carried out in diverse, intensive rice-based systems in the Indo-Gangetic region since 2010, focusing on machinery development, establishment of diverse crops, soil health, nutrient and water management, weed control, systems productivity, profitability, carbon footprint, greenhouse gas implications and commercialization through the private sector and farmer networks. A wide range of farmers and farmer organizations, extensionists, private-sector entities and scientists from national and international agricultural research and educational systems were involved.

Long-term investigations on conservation agriculture confirm its multiple benefits, including increased crop yield and profitability, improved water productivity for dryland crops, improved soil health, soil organic carbon sequestration, decreased crop production costs and weed pressure, and reduced greenhouse gas emissions.

In China, conservation agriculture has been extended and adopted to some extent, while the adoption of conservation agriculture by smallholders in Bangladesh and West Bengal in India is negligible. Major constraints to widespread adoption in these countries are farmers' mindsets, intensive cropping and systems, weed, nutrient and residue management, limited availability of appropriate and low-cost planters, socioeconomic issues and unsupportive policies. To realize the full potential of conservative agriculture, the practitioner should allocate considerable time for education and training, as it is a complex set of innovations leading to food security, soil health, family livelihoods and to the mitigation of global warming.

4.3 Innovative agricultural machinery and policies: key drivers of conservation agriculture development

Hongwen Li

Leader / Professor at the Conservation Tillage Research Center (CTRC), College of Agricultural Engineering, China Agricultural University, Beijing, China

Agricultural machinery innovation and policy have a significant impact on the development of conservation agriculture. Conservation agriculture research in China started in 1992, and conservation agriculture innovation achievements have received five National Science and Technology Progress Awards from the Chinese central government. The Chinese government has adopted strong policies to support conservation agriculture development, from technology innovation to widespread adoption. Consequently, conservation agriculture in China has evolved from a simple research project to a prominent agricultural technology endorsed by national policy. This presentation outlines the 30-year journey of conservation agriculture in China, segmented into three stages.

During the first stage, China conducted research on small-scale conservation tillage machines for areas with one crop per year on the Loess Plateau. Machines and equipment included no-till seeders, subsoilers and subsurface tillers. A technical model of conservation tillage was developed, combining no-tillage with less tillage, achieving a straw cover rate of more than 30 percent after sowing. This prompted the Chinese government to implement conservation agriculture in nation-wide demonstration and extension projects.

In the second stage, in regions where the cropping system includes wheat and maize in one year and sufficient fresh maize straw is produced to cover fields post-harvest, power-driven anti-blocking and minimum tillage sowing wheat technology was developed. The technology facilitated annual conservation tillage in these regions. This meant ploughing was not required over the course of the year and over 30 percent of the land was covered with straw. This prompted the Chinese government to formulate plans for the expansion of conservation tillage.

During the third stage, based on previous research and demonstrations and with a focus on preserving black soil in northeast China, advancements were made in the operational performance of no-tillage seeders, incorporating navigation technology, information technology and control technology. Particularly noteworthy was precision seeding performance under high-speed conditions. These developments led to the formulation of an action plan for conservation tillage on black soil by the Chinese government. Additionally, a popular comic book on conservation agriculture technology has been produced by China and translated into nine languages.

Through 30 years of cumulative technical expertise, the conservation tillage team of China Agricultural University (CAU) has not only built the China Institute for Conservation Tillage of CAU but has also built the Conservation Tillage Research Center (CTRC) and the Key Laboratory of Agricultural Equipment for Conservation Tillage under the Ministry of Agricultura and Rural Affairs. The team's exemplary work has earned recognition as an outstanding innovation team by the ministry.

4.4 Drivers for successful validation and scaling of conservation agriculture principles and practices in sub-Saharan Africa

Alfred Micheni
Director, Kenya Agricultural and Livestock Research Organization (KALRO Embu)

Climate change is an environmental phenomenon that significantly affects weather and land conditions. Its adverse effects impede agricultural development, particularly the production of adequate and high-quality

biological products at farm level. This is especially true under rain-fed farming systems, which are predominantly practised by smallholder-farmers in arid and semiarid lands. In the face of growing needs for food, fibre and revenue, farmer institutions need to embrace resilient conservation agriculture (CA) innovations and mechanization practices to produce adequate food for all families. Innovations and practices in CA are anchored on three principles: minimum soil disturbance, permanent soil surface cover and crop diversification. Improved land and food productivity are some of the possible short- and long-term benefits accrued from sustainable CA innovations and practices in arid and semiarid lands. Immediate benefits include greater soil-moisture retention and soil organic matter capitalization and recycling.

Smallholder farmers should benefit from sustainable intensification frameworks for the adoption of climate-change-resilient CA innovations, including suitable mechanization strategies.

For example, with financial support from the Australian Centre for Agricultural Research, CA-based sustainable intensification was practised in a nine-year project, from 2010 to 2018, titled Sustainable Intensification of Maize–Legume Cropping Systems for Food Security in Eastern and Southern Africa. The project aimed to sustainably increase food security and incomes for smallholder farmers in eastern and southern Africa.

Apart from the field exploratory trials that were jointly managed by researchers and farmers, the project employed computer-based software – the Agricultural Production Simulator Computer Model – to provide simulations that interpreted the possible field-production outcomes. Over 80 percent of the simulations aligned with real field observations resulting from the annual implementation of CA innovations alongside appropriate tillage and mechanization practices. This provided quick responses to the validation of agricultural technology and facilitated the adoption processes. This was strengthened by the engagement of farmer platforms, the private sector and government institutions in the scaling of accrued technological benefits. These institutions included the CA Mechanization Innovation Platforms and CA Mechanization Farmer Field Schools that were managed by farmers and local private companies and government institutions. The institutions embarked on widely scaling the various resilient agricultural innovations within and beyond the initial technological validation ecologies in arid and semiarid lands.

The overall success of the initiative was based on ongoing, large-scale outreach activities implemented by farmers and championing for diverse farming and marketing enterprises, ecologies and partners participation. The key drivers for acceptance of the resilient CA innovations and mechanization practices were savings on labour costs and increased land productivity. The study concluded that the reinforcement of appropriate agricultural-resilience innovations, management and practices lead to sustainable agricultural development, better livelihoods and economic opportunities in semiarid climatic conditions.

Parallel session: Precision agriculture

4.5 Integrating precision agriculture technologies in conservation agriculture: enhancing sustainability and resource efficiency

Liudmila Orlova
Chair of the National Movement on Conservation Agriculture, Russian Federation

Agriculture is the key to food security for people. But to ensure food security, we need a new type of agriculture that seeks to minimize the amount of external inputs (fuel, fertilizers, herbicides) used and to maximize the potential of local biological production resources (renewable energy sources, biofuel, organic fertilizers, etc.).

This presentation is focused on a new approach to agriculture that is based on the principles of conservation and precision agriculture. This approach combines practices that on the one hand aim to protect soil from erosion and degradation while preserving soil biodiversity and fertility, and on the other hand seek to integrate innovative technologies, such as self-driving machinery, drones and satellite technologies, thus providing a sustainable and efficient system.

In the Russian Federation, there is a growing trend of applying this two-pronged approach. Conservation agriculture practices are used on an area of 6 million ha, and mulching is applied on another 15 million ha as a transition technology to conservation agriculture. Elements of precision agriculture are applied on 2 834 farms in 55 regions, covering an area of 17.5 million ha, and the numbers are growing every year. Agricultural research sites are also being established in the Russian Federation to conduct comprehensive research on efficient management of carbon cycles with biological treatments to increase soil fertility, yields and production quality, prevent soil degradation, increase soil carbon storage and decrease greenhouse gas emissions.

In the Samara region, a world-class research facility and scientific centre titled "Engineering of the Future" has implemented both conservation and precision agriculture methods on an area of 4 500 ha. Constant research is being conducted by Russian and international educational and research institutions to search for and test the best methods to keep soils healthy and provide for their fertility. This is considered to be the only way to provide for sustainable agriculture and ensure food security for future generations.

4.6 Precision nutrient management in conservation agriculture: optimizing fertilizer use for sustainable crop production

Hamza Rkha Chaham
Co-founder and Chief Operating Officer, SOWIT, Morocco

FERTISAT is a decision-support tool for deciding on nitrogen fertilization of field crops (soft wheat, rapeseed, barley, sugarcane). Considering the heterogeneity of the cover at intra-plot scale, the tool proposes a segmentation of the plot into homogeneous sectors to allow fertilizer application as close as possible to the needs of the crops. It provides maps of variable fertilization created using satellite imagery.

The service offers maps for precise nitrogen fertilization of grain crops that can be uploaded to controllers of agricultural machines or analysed on a computer screen. It relies on satellite remote sensing and biophysical algorithms to evaluate absorbed nitrogen and dry matter. Knowledge of these biophysical variables makes it possible to use the INRAE nitrogen nutrition index decision-support tool.

The benefits of using FERTISAT include reduced use of nitrogen fertilizers by up to 10 percent, which allows farmers to achieve a larger profit per hectare, more effective nitrogen fertilization adapted to the current vegetation conditions as well as local humidity and topographic conditions, and continuous satellite observation of the state of crops throughout the season, which facilitates precise setting of fertilization dates and field management. The service also provides specialist support to help farmers use the service and analyse the ordered application maps.

The deployment of FERTISAT over several thousand hectares in Morocco and Tunisia highlights several challenges in the adoption of precision fertilization, e.g. connectivity, equipment spreading, the weight of non-agronomic factors in decision-making, the importance of climate factors and the weight of climate risks. These are the factors that need to be discussed as they represent obstacles to adoption, while several elements such as the cost of nitrogen and the price of wheat appear to be moving in a direction that favours the adoption of precision fertilization.

Since precision agriculture requires a holistic vision of the plot, fertilization cannot be thought of outside of sowing or irrigation.

4.7 Optimizing seed coulters for no-till direct seeding

Maik Freitag
Sales and Product Manager, Novag

Farmers till the soil for a specific purpose, but unfortunately tillage does not fulfil that purpose in the long term. Soil loss through erosion is the biggest challenge for farmers and humanity itself, and can only be ended by stopping to till the soil. To meet both challenges, the world would be better off today without tillage.

No-tillage seeding is defined as one of the principles of conservation agriculture, and it is gaining ground all over the world.

However, untilled soils pose a series of challenges for mechanized seeding, such as hard soil conditions and the presence of organic residues. Typical seed coulter designs, such as the tine coulter or disc coulter, are not always suitable for no-till conditions. Both have their advantages and disadvantages for use in no-tillage seeding. For example, a tine can cope with hard soils but not with organic residues, while a disc can cope with residues but not with hard soil. However, by adding some tools and upgrades, both types of coulters can be optimized for no-tillage practices. With an additional cutting disc in front of a narrow tine, for example, a tine seeder can be optimized to seed in organic residues with less soil disturbance.

Cognizant of the challenges of no-till practices, and motivated to resolve the problems of traditional coulters, engineers developed new coulter designs. The two most famous designs are the undercut disc and the inverted-T opener. These new coulters can cope perfectly with the challenges posed by no-tilling, but their main disadvantage is their high price.

In summary, it can be said that no-till conditions require a specialized coulter design. This can be achieved either through upgrading simple seeders or through the purchase of new ones. Thanks to the spread of no-tillage practices across the world, their development continues, and further experience will allow no-tillage seed coulters to be optimized in the future.

4.8 Precision irrigation management for water conservation in conservation agriculture: tools and strategies

Itamar Nadav
Head of R&D and Innovation, Agronomy Department, Netafim Italia

Animal farming, as well as biogas energy production, cause increasing environmental challenges due to their environmental footprint, which includes CO_2 and NO_x gas emissions, soil and water pollution by nitrates, and more. Public pressure, as well as regulation, forces farmers to find more efficient and environmentally sensitive effluent-spreading methods that are also economically feasible.

Nitrogen pollution is one of the main concerns of the European Union, which in fact limits the amount of nitrogen that can be applied to open fields, thereby limiting the practice of effluent spreading. The European Union allows 170 kg of nitrogen to be applied per hectare, annually. This limit forces farmers to find more fields to apply their effluent, increasing the cost of transport and land rental. In the European Union and the United States of America, effluent is commonly spread on a surface by a tractor pulling tankers or draglines. This practice limits spreading to early in the season, before planting, or late in the season, after harvest, when no crops are present in the field. Both spreading periods have a high risk of rainfall, which can cause high nitrogen leaching and runoff. In addition, spreading nitrogen outside of the growing season reduces efficient use of nitrogen. In some dairy farms in the United States of America, flood irrigation is still the most common practice, and when dairy farm effluents are diluted in the flood water, the risk of nitrogen leaching increases.

Our solution is to use a drip irrigation system as an effluent-spreading mechanism, where the effluents are filtered and diluted in water and applied during irrigation in small quantities. Experiments have been conducted to this end.

In a biogas facility pilot project, effluents were diluted in a 1:10 ratio with freshwater for corn irrigation using subsurface drip irrigation. In this experiment, nitrous oxide emissions were reduced by almost 50 percent compared to conventional surface spreading. In a dairy farm in California, United States of America, effluent spreading with subsurface drip irrigation reduced the use of nitrogen by 4 percent and reduced water application by 35 percent, compared to flood irrigation with effluents. The experiments demonstrate alternative methods for economical and sustainable disposal of effluents from animal and energy production using a simple drip irrigation system.

Chapter 5
Digitalization and automation

Parallel session: Digital technology and information and communication technology

5.1 Low-cost internet-of-things devices along with information and communication technology can help irrigation decisions for smallholder farmers

Clémence Uwamutarambirwa
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The internet of things (IOT) is a network of physical objects – "things" – embedded with sensors, software and other technologies for connecting and exchanging data with other devices and systems via the internet. Meanwhile, information and communication technology (ICT) is defined as a diverse set of technological tools and resources used to transmit, store, create, share or exchange information. These technological tools and resources include the internet, information storage and broadcasting technologies.

Irrigation, increasingly practised all over the world, is an essential practice in agriculture since water availability is never a constant parameter.

The efficiency of irrigation systems depends on numerous factors including the quality of the infrastructure in use. As this requires financial inputs, finances are a limiting factor.

Technology has significantly eased the practice of irrigation by introducing automated systems that increase precision and efficiency. Today, advanced sensors and monitoring devices can measure soil-moisture levels, weather conditions and crop needs in real time, allowing for precise delivery of water. Additionally, automated irrigation systems can be remotely operated and scheduled, reducing the need for manual labour and ensuring that water is distributed optimally. This highlights the ongoing need for modern technology in irrigation systems.

IOT technology partnered with ICT significantly alleviates financial constraints in irrigation systems. It enables data-driven decision-making, efficient resource management, remote monitoring and control of farm system water levels and predictive maintenance of equipment. All these factors play a major role in reducing difficulties in decision-making and financial hurdles.

In conclusion, the integration of IOT and ICT technologies into irrigation systems offers a multifaceted approach to addressing financial constraints in agriculture, which are a difficult burden for smallholders around the world. Their association can empower farmers to operate irrigation systems more efficiently and economically.

My most pressing recommendation is that farmers and agricultural stakeholders embrace this technology to increase efficiency and overcome financial burdens. Implementing the use of IOT devices and integrating them with ICT systems should be a priority for those seeking to optimize resource management, minimize downtime and prolong the lifespan of irrigation equipment. This would be a winning formula for the agricultural sector in low-income countries where a larger proportion of farmers are smallholders.

Governments and agricultural organizations are equally encouraged to support the adoption of IOT technology by providing incentives, training and access to affordable IOT solutions to ensure that this innovative approach becomes accessible and beneficial to a wide range of farmers.

5.2 Information and communication technology and telematics: its role in supporting the future of on-demand service and automation of smallholder farm assets

Jehiel Oliver
CEO, Hello Tractor

Smallholder farmers do not have the machinery they need to fully cultivate their land. Tractors and farm equipment are expensive, and financing is virtually non-existent. However, if a farmer has access to a tractor, that is as good as owning one.

Hello Tractor is a driving force behind global agricultural advancement. Our technology-centric approach offers an IOT fleet-management software solution and marketplace that facilitates direct connections between farm-equipment owners and contract-seeking farmers. Spanning 16 African nations, we reach over a million small farmers with over 4 500 tractors and combine harvesters. We are proud to introduce a new pay-as-you-go tractor finance product and hub model, enhancing our commitment to community-driven progress. In a world where agriculture contributes 40 percent to Africa's GDP and 60 percent of its labour force, Hello Tractor's solutions are instrumental in bridging productivity gaps and transforming lives.

5.3 Digital technologies and the use of information and communication technology can empower smallholder farmers to boost their yields and increase their income

Worlali Senyo and Princess Anita Asabere
Farmerline, Country Manager Ghana

Smallholder agriculture represents the majority of global food production, with over 80 percent of the estimated 570 million farms worldwide classified as smallholdings, providing over 80 percent of the food supply in Asia and sub-Saharan Africa. Climate change presents an existential threat to the livelihoods of smallholder farmers and agricultural small- and medium-sized enterprises across the developing world. These vulnerable groups urgently require accelerated access to climate financing, appropriate financial products and climate education to build resilience and adapt their practices to a changing climate. Digital technologies can play a pivotal role in surmounting current limitations and delivering sustainable solutions at scale.

Farmerline is a dynamic agritech social enterprise focused on creating a marketplace that combines digital tools, logistics, agents, farm resources and agribusiness partnerships to support African smallholders. Initially serving 800 farmers in Ghana's Ashanti Region upon its launch in 2013, Farmerline has since expanded its support to directly serve over 300 000 smallholder farmers through a last-kilometre network of local agro-SMEs and young entrepreneurs, and indirectly reach over 1.7 million farmers through partnerships with organizations across 48 countries through its Mergdata farmer services and training platform.

The platform applies alternative data and novel credit scoring models to provide tailored financial products to farmers and agribusinesses with limited formal credit history. Farmerline posits that digitally enabled climate financing and capacity building are indispensable to bolstering the resilience and sustainability of agricultural livelihoods across the developing world. Moreover, unlocking these innovative solutions at scale necessitates urgent, concerted efforts through strategic partnerships with high potential to secure food security and drive climate change mitigation.

5.4 "Agriculture digital twins" are the next step in digital technology, and have the potential to provide individualized information and suggestions for smallholder farmers

Simon van Mourik
Researcher, Wageningen University and Research

A digital twin (DT) is a virtual representation of a physical object or system, that is updated from real-time data and uses simulation, machine learning and reasoning to help decision-making.

It is essentially a digital replica of a system that adapts its parameters and states using sensor data via mathematical algorithms. The goal of a DT is to achieve actionable knowledge and, as an extension, a prediction of the best set of inputs or actions given a specified performance criterion (usually to balance between the cost of inputs and actions and production revenues) (Knibbe *et al.*, 2022).

The presentation focused on the opportunities and challenges for exploiting DT technology to improve operational management regarding precise timing, dosage and allocation of inputs and actions for maximal resource efficiency according to the precision farming model. Specifically, digital twinning is used for automated prediction of system response towards inputs and actions (e.g. climate control, crop handling and irrigation), diagnosis, state and parameter estimation (to automatically learn from data) and ultimately automated control (or control advice).

It was shown how the precision farming-DT model applies to low-tech smallholder farms just as it does to high-tech farms. For cognitive tasks (prediction, observation, diagnosis and control), the required skills (such as predicting systems response, learning from data, state estimation, planning ahead and risk mitigation), can be fulfilled through mathematical models and algorithms that form the DT.

The question arises as to why every farming system is not completely automated. Several factors may form a gap between reality and the idealized assumptions behind a mathematical method, thereby limiting system performance (van Mourik *et al*., 2021). These include: system complexity (due to the large number of biological and physical processes, nonlinearity and different time scales), external uncertainty (caused by weather, diseases and market prices), and internal uncertainty (caused by unmodelled biological or spatial variation, and parameter uncertainty), monitoring limitations (due to sensor noise and unobservable states), and actuation limitations (due to capacity limitations and the fragility of crops and animals).

In conclusion, the precision farming-DT model provides great opportunities for automated decision support in smallholder farms, in terms of labour and resource efficiency, but also in the sense of challenging research projects that require an interdisciplinary approach (mathematics, statistics, physiology, (information) technology and ecology) for modelling and control for farming DTs under the theory–reality gap.

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Parallel session: Automation and artificial intelligence

5.5 Artificial intelligence and smart app technologies can provide scalable and automated plant-health advice to farmers around the world

Simone Strey
CEO, Plantix

Small-scale farmers sow food that we need, yet their toil is often hidden in the shadow of poverty. They struggle against the odds, battling not just nature but having very limited access to knowledge, resources and technology. These unsung heroes feed the world, but their struggle is real, and we feel it is our responsibility to empower them with the tools they need.

Plantix has been created against this background, to make AI technology work with nature to ignite a revolution in agriculture. Plantix is a revolutionary, entirely free app designed to level the playing field for small-scale farmers worldwide. It is an app that helps farmers diagnose and treat sick crop problems just by taking a photo.

Using AI technology, data analytics and scientific research, our goals are to provide the right solutions for small-scale farmers, promote sustainable practices and boost farming productivity. Plantix transforms Android phones into mobile crop doctors, diagnosing pests and diseases within seconds.

Plantix's main features are:

- Heal your crop – detects crop pests and diseases and suggests recommended treatments.
- Dukaan – an online marketplace where farmers can find the right treatments nearby, discover local agricultural products and compare prices.
- Farmer community – connects farmers with 500+ community experts for any answers to their crop-related questions.
- Disease alerts – farmers can be the first to know when a disease threatens their area.
- Crop library – an online library where farmers can find any information to maximize their yields.

The main benefit of Plantix is that it empowers farmers to act quickly, preventing further losses as well as reducing losses. It gives farmers free access to plant diagnosis within 1.7 seconds using Plantix's image-recognition technology. The vibrant community of Plantix users ensures that wisdom flows freely, benefiting all. Ninety percent of its users report improvements in their farming practices, 50 percent report decreased household expenditure, and 80 percent report an overall improvement of their quality of life.

Plantix covers 30 major crops and detects over 600 plant damages. While farmers are supported worldwide, India is at the heart of Plantix's efforts, with availability in 18 languages and over 35 million downloads, it has become the most-used agricultural app for damage detection, pest and disease control, and yield improvement.

In the past year, we have provided 50 million pieces of advice to farmers, made 10 million disease diagnoses, and facilitated 4.5 million product searches.

Plantix stands out with its user-friendly blend of image-recognition technology and extensive plant database. It excels in pinpointing plant issues, offering precise diagnoses and delivering actionable solutions.

5.6 The automation of precision-spray applications with artificial intelligence support can deliver crop protection from drones for smallholder farmers in a scalable and robust manner

Justin Gong
Co-founder and Senior Vice-President, XAG Company

By 2030, the global population is projected to reach 8.5 billion, consequently increasing the demand for food (United Nations, 2022). However, this growth coincides with challenges including dwindling rural populations and climate change, which threaten the foundations of food security and agriculture. To address these pressing concerns, a shift towards smart agriculture technologies is imperative.

As an organization dedicated to smart-agricultural innovation, XAG embarked on a groundbreaking venture at a "super cotton farm" in China. Two young men in their twenties who had never farmed before harnessed the potential of intelligent agricultural technologies to manage a 200 ha cotton field. Leveraging an array of automated technologies, including surveying drones, agricultural drones, unmanned ground vehicles, an IOT system and farm-management software, the XAG Super Cotton Farm has achieved top-level yields over three years. This has demonstrated the viability and sophistication of smart agriculture technologies.

The presentation unveiled XAG's smart-agriculture solutions, integrating drones, robotics and AI technologies. It delved into XAG's journey of promoting and localizing smart agriculture solutions across 57 countries and regions, illustrating how this holistic approach has empowered both small-scale and large farms.

The discourse of XAG extends to the practical use of these technologies in diverse agricultural contexts, and we seek to inform the audience about current smart agriculture technologies by sharing XAG's experience in promoting these technologies to global farmers.

5.7 Training the next generation of farmers in the use of digital technologies and information and communication technologies is important for the inclusive adoption drone technologies

Tawanda J. Chihambakwe
Director at Precision Aerial Group, Flying Labs

Precision Aerial Group was founded in Zimbabwe in 2016 and operates across southern Africa. They provide key services and solutions for drone technologies for agriculture in Africa, such as turnkey drone technology integration programmes, drones as-a-service and training for organizations and individuals.

Group companies are: Precision Aerial Services, Zimbabwe Flying Labs, Precision Drone Training and the Zimbabwe International Drone Conference.

Technological advances, particularly emerging technologies such as drones, robotics, AI and IOT have made it possible to overcome challenges faced by farmers in the global South and to leapfrog some of the infrastructure gaps that exist.

The use of drones for crop protection is a leading tool in precision agriculture and offers advantages compared to manual tractor-drawn spraying. Spraying drones are UAVs that can be programmed to fly over crops, apply pesticides, fertilizers or foliar sprays.

The use of drones for commercial applications is legislated through laws and regulations that govern their safe and legal use. In Zimbabwe and several other countries, drones can only be operated by trained and licensed operators. Spraying drones can weigh up to 50 kg with a full payload, Zimbabwe Flying Labs has pioneered the use of crop-spraying drones in Zimbabwe and has established a drone training school, certified by the national civil aviation authority, to train operators on the safe and effective use of the technology.

Zimbabwe Flying Labs provides services and consultancy to farmers, farming organizations, agriculture institutions and government departments including the Zimbabwe ministry of agriculture. As drones become larger and more efficient, the demand for crop-spraying services is rising. Crops for which farmers hire drone services include maize, sugarcane, soybean, sorghum, wheat, cotton, sunflowers, citrus, macadamia nuts, blueberries and tea.

The benefits of spraying with drones compared to traditional methods include:

- covering larger areas in a shorter time;
- reducing the amount of water required for spraying by almost 90 percent;
- reducing labour costs;
- providing real-time data on crop health;
- providing more precise and uniform application of products, which:
  a) reduces chemical waste and minimizes environmental harm, and
  b) produces better crop growth, better disease management and higher yields.

The rise in the use of crop-spraying drones in Zimbabwe is helping farmers improve their profitability and sustainability.

5.8 Experiences and learnings of an agricultural robotics and artificial intelligence start-up in Latin America

Leo Carvalho
Chief Global Strategy Officer, Solinftec, Brazil

In today's landscape, where the convergence of technology and agriculture plays a crucial role in the pursuit of food security and sustainability, the story of Solinftec, an agricultural robotics and AI start-up, is an inspiring model of success and tangible value delivered to producers. The journey taken by this company shows important lessons for start-ups in Latin America and beyond, proving that the determinant of success is the ability to demonstrate value to producers.

Many start-ups entering the agricultural sector are known to struggle to prove their value to producers, resulting in high rates of failure. However, Solinftec emphasizes the importance of identifying real problems that farmers face and solving them in a simple and effective way. The start-up takes on a central challenge: how to turn technology into a tangible ally, increasing the profitability and sustainability of producers.

The combination of food security and sustainability opens doors to unprecedented opportunities, and when data analysis is translated into concrete results and real-time actions, the chances for success multiply.

In this context, innovation manifests itself as the epicentre of Solinftec's journey. The start-up is not only revolutionizing agriculture through the application of cutting-edge robotics and artificial intelligence, but also redefining the boundaries of sustainability. The launch of a technologically advanced robot powered by solar energy and batteries not only reduced dependence on fossil fuels but also reduced soil compaction. This innovation not only positions Solinftec at the technological forefront, but also underlines its commitment to environmental preservation.

Chapter 6
Supply chain and standards

Parallel session: Supply chains and services

6.1 Major trends and opportunities in agricultural mechanization supply chains

Charlie O'Brien
Secretary General, Agrievolution

The agricultural sector is undergoing a profound transformation driven by technological advances in mechanization and supply-chain management. Many stakeholders are impacted by this change including, but not limited to, machinery-repair and maintenance services, machinery-hire services, policymakers, farmers, manufacturers, importers and retailers.

This presentation explores major trends in agricultural mechanization supply chains, with a focus on supply-chain disrupters, shortages in microchips and the growing influence of AI in shaping the future of supply chains within the agricultural-mechanization sector.

Agricultural mechanization has historically relied on a linear and segmented supply-chain model, comprising manufacturers, distributors, dealers and end users. However, this traditional model is being disrupted by a shift towards more integrated and digital supply-chain solutions. The emergence of digital platforms and data-sharing technologies is enabling real-time communication and collaboration across the entire supply chain. This trend promotes transparency, efficiency and responsiveness, resulting in streamlined operations, reduced lead times and increased customer satisfaction. Manufacturers and suppliers are adapting to this trend by investing in digital infrastructure, integrating IOT devices and utilizing predictive analytics to optimize production, inventory management and distribution processes.

The pandemic severely crippled the entire supply chain, especially for providing microchips. Microchips are essential components in modern farm equipment, powering crucial functions such as precision agriculture, autonomous operations and data analysis. However, the imbalance between supply and demand for microchips has led to production delays and increased costs in the agricultural-mechanization sector. Manufacturers are being compelled to seek alternative supply-chain strategies, such as diversifying suppliers and adopting chip-saving design practices. This situation highlights the vulnerability of modern supply chains to unforeseen disruptions, prompting stakeholders to explore strategies that balance efficiency with resilience.

In conclusion, the agricultural mechanization supply-chain landscape is undergoing transformative changes driven by various trends and disruptions. The shift towards integrated and digital supply-chain solutions is enhancing transparency and responsiveness as suppliers evolve their relationships with agricultural equipment manufacturers.

6.2 Overcoming constraints in spare-parts supply and machinery-maintenance services

Yahia Khalifa
CLAAS Marketing responsible for Africa and the Near East

For any agricultural manufacturer, the decision to be present in Africa or to operate through an importer is difficult and has implications on the future of the organization. Both options have their own respective benefits and drawbacks.

Building a factory in Africa has the advantage of providing direct control over operations, production quality and aftersales services. Challenges include volatile and unpredictable customer demand, limited infrastructure in many areas, the need to import components and materials, the difficulty to find and retain skilled staff, volatile social and security situations, inflation and unstable exchange rates. Building the factory is in itself challenging, requiring the import of materials, equipment and skilled individuals.

Operating in Africa through an importer or partner has advantages: it allows the company to be present at a reduced cost, to benefit from the importer's network of customers and to limit exposure to risk. Challenges include the difficulty in finding a suitable partner with sufficient financial resources. Volatile consumer demand also impacts the importer, and they will be reluctant to hold large volumes of stock. Long lead times for importing machinery or parts make it hard for importers to deal with sudden spikes in demand. Furthermore, good aftersales services require a good dealer network and supply of parts, which can be difficult to achieve due to the distance, lack of skilled mechanics, tool costs, machine ages, long lead times and customer maintenance habits.

Choosing a strong importer is vital as their actions and performance will reflect on the company and brand. A poor importer can cause considerable damage while a strong importer can become a key element for growth within Africa.

Both options require due planning. While it is not impossible to have a strong presence in Africa and develop the market, companies need to think of solutions such as financing or lobbying solutions with the local government, for example to reduce taxes and tariffs on machinery, remove restrictions on currency exchanges, create programmes that develop and empower agriculture within the country, train local farmers, encourage and incentivize commercial banks to invest in and make loans available in the agricultural industry.

6.3 Business models for mechanization supply-chain integration

Tie Li
Chair, CAMCO

The rapidly evolving world of business has seen a shift in the manner products are created, delivered and consumed. One sector that is experiencing significant transformation is the agricultural mechanization sector. CAMCO contributes to the agricultural sector through the mechanization supply chain integration business model. With its head office in Shanghai, China, CAMCO aims to expand its presence to African regions. Since

1998, CAMCO has operated from Lusaka, Zambia, and has expanded with direct operations in Cameroon, Kenya, Malawi and the United Republic of Tanzania.

CAMCO's business is based on the integration of mechanization and the supply chain in the agricultural sector, offering services including the provision of equipment, aftersales support, back-up spares, skills training and agricultural-machinery hire, allowing farmers to ensure timely farming operations, decrease reliance on manual labour, mitigate health risks associated with manual tasks, augment in-farm revenue due to increased productivity, champion large-scale farming leading to heightened output and nurture community development and collaboration among farmers.

CAMCO supplies a variety of agricultural equipment such as LOVOL tractors (from 35 hp to 230 hp), walking tractors, tractor implements such as ploughs and planters, combine harvesters, agricultural trailers and diesel engines for various purposes.

Hiring machinery is a practical solution for financially constrained farmers, allowing them to realize their agricultural aspirations without the burden of upfront investment. Farmers with smaller land holdings are advised to tailor their strategies, ensuring that they optimize productivity and maximize yields, all while working within the confines of their limited space.

CAMCO puts emphasis on education and training, evident in the establishment of CAMCO College in 2020. Registered with the Technical Education, Vocational and Entrepreneurship Training Authority of the Government of Zambia, it provides courses from machinery operation to professional driving and machinery repair. The curriculum is strategically designed to teach farmers the skills needed to operate and maintain agricultural machinery and equipment.

CAMCO promotes agricultural mechanization by introducing tailored financing schemes suited for varied financial needs, including offering instalment payment plans. By collaborating with financial institutions, including banks and leasing companies, CAMCO has made it possible to reach out to farmers even in the most remote parts of the country. Furthermore, government support through mechanisms, such as the Constituency Development Fund and the Citizen Economic Empowerment Commission, has paved the way for numerous farmers to embrace mechanization.

The integration of mechanization within supply chains is not just about replacing manual processes with machines. It is about making the entire supply chain more efficient, agile and responsive to market needs. As technologies continue to evolve, it is paramount for businesses to adapt, ensuring they remain competitive and resilient in the face of change.

6.4 The Mining, Agricultural and Construction Equipment Protocol: an international framework for asset-based financing of equipment

Priscila Andrade

Legal Officer, International Institute for the Unification of Private Law (UNIDROIT), Italy

Financing mining, agricultural and construction (MAC) equipment is challenging in many parts of the world. Financial institutions are unwilling to provide credits to purchase or lease equipment due to uncertainty created by domestic laws, the possible movement of assets across borders or challenges in enforcing their rights upon default or insolvency. Consequently, the entities involved lack the ability to acquire the equipment needed to improve productivity and performance.

The MAC Protocol was developed by the International Institute for the Unification of Private Law (UNIDROIT) to address these issues. Adopted by a Diplomatic Conference of 42 States in 2019, it provides an international legal framework for the financing of and the creation, registration and enforcement of legal interests in MAC equipment. It is an extension of the successful 2001 Cape Town Convention and its Aircraft Protocol, which has 86 Contracting States.

By improving the strength of legal interests in MAC equipment, the protocol allows lenders to increase the availability of credit, which provides farmers with access to agricultural equipment that was previously unavailable to them.

The MAC Protocol benefits a variety of different stakeholders:

- farmers, construction companies and mining entities benefit from increased access to modern equipment at a lower cost, increasing mechanization, productivity, profitability and yields;
- manufacturers benefit from higher demand for their equipment, increasing output;
- dealers and traders are able to export and import more equipment and begin operations in new markets; and
- financiers benefit from greater legal protection for issuing credit, which allows them to provide cheaper financing and expand operations to new markets.

According to a 2018 independent economic assessment, the protocol may increase the stock of MAC equipment by USD 90 billion over 10 years. In doing so it will increase the annual GDP of developing countries by USD 23 billion and the annual GDP of developed countries by USD 7 billion, for a total impact on global GDP equivalent to USD 30 billion a year.

By facilitating mechanization and the adoption of new precision agriculture technologies, the MAC Protocol will have significant environmental benefits in terms of higher productivity and lower fertilizer, herbicide, fossil fuel and water usage.

Countries must ratify the MAC Protocol to enable its legal and economic benefits. While five countries have already signed the MAC Protocol, the treaty requires five ratifications to enter into force. Countries are encouraged to work with UNIDROIT to implement the MAC Protocol to improve their legal frameworks, boost trade, increase mechanization and improve economic development.

Parallel session: Automation and artificial intelligence

6.5 Benefits of standards (operator safety, efficiency and reduction of food loss, harmonization, trade strengthening, networking among testing stations)

Julia Nielson
Deputy Director, Trade and Agriculture, Organisation for Economic Co-operation and Development (OECD)

The Organisation for Economic Co-operation and Development (OECD) Standard Codes for the official testing of agricultural and forestry tractors are a set of rules and procedures for tractor testing with the aim to facilitate trade by updating international rules to certify tractors and their protective structures.

Implementation of the codes ensures that protective structures and performance criteria of tractors are carried out on a comparative basis, thus increasing transparency, simplifying international trade procedures and opening markets.

The OECD tractor codes were established in 1959, and are currently followed by 27 member countries across three continents and have a network of 30 testing stations worldwide.

Over 13 000 tractor models around the globe have been tested using the OECD tractor codes. This highlights the benefits of a mutually recognized standards system and its impact on trade, labour safety and food security.

Facilitating trade: tests carried out in one Member Nation are recognized in ALL Member Nations. The volume of trade in tractors is 33 percent higher when both trading partners are OECD tractor codes members.

Increasing labour safety: reduction in number of fatal tractor accidents.

Enhancing food security: promotes sustainable agricultural mechanization.

Farmers and other stakeholders can benefit by comparing the safety and technical reliability of different tractor models and choose the one that better suits their needs.

Further reading
www.oecd.org/agriculture/tractors

6.6 Newly established testing stations perspective on standards and regulations; challenges and needs

Shreemat Shrestha
Chief, National Agricultural Engineering Research Centre, Nepal Agricultural Research Council; Vice-chair ANTAM 2023

In the last two decades, increased migration by young people in search of other jobs from rural areas to cities and abroad has created a scarcity of labour during the peak agricultural season in Nepal. This has led to an increased demand for agricultural machinery, which was further strengthened by government-supported subsidy programmes. Over the past three years, an average of more than USD 150 million of agricultural machinery has been imported into Nepal each year.

In the past few years, issues regarding machine quality have been raised by farmers and technicians. The Government of Nepal initiated several efforts to ensure the quality of agricultural machinery, not only to deliver the desired performance of the machinery but also to promote safe agricultural machinery use.

In this presentation, experiences in agricultural-machinery testing, certification and standardization in Nepal are discussed.

The Agricultural Machinery Testing and Research Centre was established by the Nepal Agricultural Research Council to create a test facility for agricultural machinery in the country. At present, the Centre is equipped with a facility to test 5 hp to 25 hp engines for vibration, noise, brakes, the turning radius of the mini tiller and power tiller, and for the field performance of other agricultural machinery.

Following consultations with stakeholders, the machinery prioritized for testing were: mini tillers (both petrol and diesel engine), sprayers (knapsack and power sprayers), chaff cutters (manual and power), threshers (pedal and power operated), greenhouses, drip irrigation systems, hand tools and power tillers.

The Nepal Bureau of Standards and Metrology has taken the lead in preparing national standards for the prioritized agricultural machines. Similarly, the Nepal Ministry of Agriculture and Livestock Development has introduced testing and certification schemes and a legal framework for testing and certifying agricultural machinery. Multiple stakeholders are involved in establishing test and certification systems for agricultural machinery in Nepal. Regular dialogue among institutions to carry out their roles in establishing and strengthening the system is important.

Other major aspects regarding the testing and certification of agricultural machinery are the establishment of test facilities, human resource development, legislation for testing and awareness-building on the importance of test and test certification at all levels. It is expected that after the establishment of the agricultural machinery testing and certification system, Nepalese farmers will have better access to quality and safe agricultural machinery to enhance their agricultural productivity and profitability in a sustainable manner.

6.7 Agriculture machinery regulations and standards: extension services, capacity building and farmer needs (including gender perspectives)

Margaret Mangheni
Professor for Extension, Makerere University, Uganda
with the support of
Shona Nabwire, *Agricultural and Biosystems Engineer*
Elizabeth Asiimwe, *Agricultural Extension and Food Systems Expert*

Mechanization has the potential to transform smallholder agriculture by increasing productivity, reducing drudgery and, ultimately, improving livelihoods. However, the adoption and impact of mechanization among smallholder farmers is influenced by intricate gender dynamics and the effectiveness of extension services.

In the predominantly patriarchal landscapes of Africa and Asia, where smallholder agriculture is a lifeline for communities, deeply embedded gender norms in various societies define identities and roles of men and women, as well as their access to and control over productive resources and services, including farm machinery. Women make up a substantial portion of the agricultural workforce; however, they face challenges in accessing machinery suited to women's ergonomic needs or the tasks they perform. These challenges are compounded by limited land ownership, financial constraints and cultural norms. Consequently, an overarching gender gap in access to mechanization persists. While mechanization holds the promise of lightening the labour burden, it is critical to recognize that gender-blind approaches might inadvertently reinforce existing disparities. Mechanization can potentially alter traditional labour dynamics. Mechanizing operations handled by men, such as primary land preparation, and not those of women, such as weeding and harvesting, may increase women's workload.

There is growing evidence that mechanization shifts the allocation of labour within households, presenting both opportunities and challenges. While it has been found to reduce drudgery associated with labour-intensive tasks, it can also disrupt established gender roles as well as be blind to the "invisible" social reproductive and productive roles of women. Men's roles in operating machinery might overlap with tasks traditionally performed by women, leading to potential tensions. Recognizing and addressing these dynamics is pivotal to ensuring that mechanization serves as an instrument of empowerment rather than exacerbating gender disparities.

The transformational potential of mechanization also hinges on effective extension services that facilitate technology transfer, skill development and knowledge dissemination.

Extension services can act as bridges connecting smallholders to mechanization. They can help identify needs and the technologies to meet them. It is therefore critical that they participate in innovation design. In areas where farmers cannot afford individual machinery, extension services can help organize farmers for group ownership and management of machinery using approaches that are sensitive to the diverse needs of women and men. Tailoring training programmes, demonstrations and advisory services to align with the specific constraints faced by women in mechanization can foster their active participation and decision-making in the adoption process.

Institutional frameworks and policies play a crucial role in shaping the gender-based impacts of mechanization. Collaboration between governmental bodies, non-governmental organizations and private-sector stakeholders is essential to create an enabling environment that supports gender-equitable mechanization. Research and machinery design teams should include gender and social-science expertise to work alongside engineers, thus ensuring innovations are suited to the sociocultural context.

In conclusion, harnessing the potential of mechanization to support smallholder livelihoods requires a comprehensive approach that acknowledges and addresses gender disparities, tailors extension services and empowers small-scale farmers, both women and men, as active participants in the transformative process. Ultimately, a gender-responsive and inclusive approach to mechanization can pave the way for sustainable agricultural development and more equitable societies.

6.8 Benefits of standardization for safety; robotics and innovation; regulations and subsidization for decarbonization and reduction of toxic substances

Shyam Narayan Jha
Deputy Director-General, Indian Council of Agricultural Research, Department of Agricultural Research and Education, Ministry of Agriculture and Farmers' Welfare, New Delhi, India

Standardization is a tool to foster safety, innovation and sustainability. Regulations and policies are made for subsidies, decarbonization and implementing standards and new innovations. There are huge benefits for standardization, including ensuring safety in driving robots and innovation, and implementing regulations for decarbonization. The Bureau of Indian Standards (BIS) and the Bureau of Energy Efficiency (BEE) in India – similar to standard setting organizations in other countries and the International Organization for Standardization (ISO) at global level – play pivotal roles in enhancing safety and the comfort of people by developing standards and operational guidelines.

A robot is an automatically controlled, multipurpose machine, reprogrammable in three or more axes, which either remains fixed or mobile in industrial applications, farm operations and household activities. Innovations in agriculture, including in harvest and post-harvest, are rapidly transforming the industry. Standardization includes requirements for safety, effectiveness and efficiency during the design, manufacture, operation and aftersales support processes. Standardization in agricultural machinery targets worker safety, machine performance and ergonomics, and ensures quality and confidence in the machinery. BIS sets out a common set of standards to facilitate product integration and compatibility. Standardized practices drive adoption of innovations and productivity with greater safety.

Amid growing environmental concerns, governments are developing numerous regulations, guidelines and subsidy schemes for safer and efficient application of innovative technologies, while BEE and BIS are establishing the associated standards. BEE sets energy-efficiency standards for appliances and equipment, encouraging their adoption to reduce carbon emissions. This work is complemented by BIS, which develops standards for cleaner and safer technology.

The significant reduction in accident rates, as compared to those in the 1980s, in operations of crop threshers and chaff cutters is a real example of the benefits of standard and regulations. *In situ* crop-residue management using machinery is a true success story of decarbonization in Indian agriculture.

Government policies, guidelines and schemes for promoting the use of happy seeders, super seeders and smart seeders have successfully reduced instances of paddy crop residue burning in fields to allow for timely wheat sowing by approximately 50 percent. This has also resulted in a 2.7 percent higher wheat yield, reduced water use by 25 percent water and urea use by approximately 20 kg/ha, and contributed to the decarbonization of the environment. Direct-seeded rice and zero-till drills are some other innovations being promoted to reduce input costs and greenhouse gas emissions. The use of innovative technologies has reduced post-harvest losses by about 2 percent. Improved infrastructures are also saving about 30 to 40 million tonnes of food annually, thereby reducing tonnes of greenhouse gas emissions.

Hydrogen fuel development from crop residues, electric vehicles, tractors, autonomous vehicles, robots and sensors and automation technologies are a top priority. Electric vehicles saved 102.7 million litres of fuel per day in India. In the last four years, approximately 39 820 million litres of fuel were saved and carbon emissions declined by over 5 770 million tonnes. India has reduced its emissions rate by 33 percent over 14 years, and is on the way to meet a commitment to the United Nations Framework Convention on Climate Change to reduce emissions intensity by 45 percent between 2005 to 2023, as the use of renewable energy sources rose significantly and forest cover increased sufficiently.

Standardization, regulations and subsidies are the need of the hour; innovations and safety requirements must keep pace in order to decarbonize successfully.

Chapter 7
Business models and multistakeholder mengagement

Parallel session: Inclusive business models

7.1 Enhancing partnership with smallholder farmers, dealers and financial institutions in agricultural mechanization

Paul Christopher Richards
CEO, AgLeaseCo, Zambia

There are many excellent and deserving public- and private-sector, NGO and community-based initiatives taking place in the small-scale and emergent farming (SCEF) space in Zambia, particularly in the areas of mechanization and market-force dynamics. However, not enough focus is given to SCEF needs, either upstream or downstream from planting and harvesting, which results in:

- mechanization not being able to mitigate the fundamental risk of crop failure in dryland farming when access to water is not secured; and
- demand-led market forces pushing the poorest farmers into being "price-takers" and accepting whatever price they are offered.

Promoting collaboration and forming effective strategic alliances between the different players in this ecosystem does not seem to be a top priority for many stakeholders in the sector. As such, the inability to leverage the previous experience(s) of other farmers and their areas of expertise results in missed opportunities and the realization that the value chain is always only as strong as its weakest link.

Together, we can be more than the sum of our individual parts.

AgLeaseCo's raison d'être is the "mechanization of Zambian farms to improve livelihoods and food security". By offering financial leasing to Zambian farms of between 5 ha and 20 ha of cultivated land, AgLeaseCo plays a crucial role in the SCEF value chain. This target market is under-banked by the traditional commercial banking sector due to the general absence or unavailability of:

- collateral, besides the equipment being financed;
- third-party guarantees that reduce residual risk to the financier;
- financial statements that provide a backward-looking trend analysis; and
- forward-looking bankable business plans accompanied by cash-flow forecasts.

The funding that AgLeaseCo's shareholders and external funders make available for injection into the mechanization of Zambia's SCEF sector is the hub around which all other initiatives in this space revolve.

Finance is required to bring life to training and technical assistance offered to farmers. Worthy and commendable initiatives such as agronomic literacy, technical training and conservation agriculture, therefore, have limited impact if not backed by access to finance.

At AgLeaseCo, we are currently exploring significant challenges that we would like to discuss with other stakeholders involved in this ecosystem. Working groups could focus on topics such as:

- ensuring mechanized water security, either electrical or solar powered, before introducing mechanized implements, eliminating a fundamental risk to successful agricultural enterprises of all sizes; and
- introducing more commercially viable storage solutions for SCEF that will enable a post-harvest "hold" play, rather than forcing this segment of the agricultural-production chain to become price-takers at a time when commodities are flooding the market.

7.2 Inclusive business models: sustainable agricultural mechanization in Kenya

Joshua Irungu

County government of Laikipia, Kenya

Kenya, located in the heart of Africa, has an agricultural sector that plays a pivotal role. Its contributions to the economy are significant: it contributes 26 percent of the country's GDP, 65 percent of total national exports, and employs 18 percent of the formal and a staggering 70 percent of the informal labour force. Furthermore, 70 percent of Kenya's rural population depends on the agriculture sector for their livelihoods. Currently, agricultural production systems in Kenya rely on a combination of human labour (50 percent), animal draught power (20 percent) and motorized power (30 percent).

To bolster the sector's sustainability, a crucial partnership has emerged between the County Government of Laikipia and FAO, with a focus on conservation agriculture and mechanization for smallholder farmers. This partnership extends to the training of farmers in conservation agriculture techniques and the use of mechanization tools such as jab planters, two-wheel tractors, ox-drawn tractors, shallow weeders, reapers and sprayers. The FAO contribution has been instrumental in supporting Kenya's efforts towards achieving sustainable agriculture, food security and rural development.

Despite successes in achieving a 15 percent adoption rate and reaching underrepresented groups such as women, persons with disabilities and older people, there are challenges to address. Slow and low adoption of mechanization technologies, inadequate access to these technologies and a lack of adequate credit and finance for farmers and service providers pose significant obstacles. Moreover, limited business development support, market linkages and a shortage of service providers and fabricators need attention.

Several initiatives have been put in place by the government to support mechanization in Kenya. These include the County Aggregation and Industrial Park, which supports aggregation of farmer commodities and products and their value addition. The government provides common mechanization utilities for value-addition processing and marketing in priority sectors such as beef, leather processing, high-value fruit trees, soybean, tomatoes and maize. Farmer field schools, training centres, model farming, fabrication and showcasing of mechanization, and agricultural shows all play a part in advancing mechanization.

These initiatives are driven by the government's development blueprint, the Bottom-Up Economic Transformation Agenda, aimed at achieving agricultural transformation and inclusive growth. The business model involves collaboration between government agencies, private-sector companies, NGOs and farmer organizations to create a comprehensive and sustainable approach.

Recommendations for further progress:

- increase capacity building training, and awareness among farmers on mechanization technologies and utilization;
- train additional manufacturers to bring mechanization service providers closer to farmers;
- establish a fund to support mechanization service providers and manufacturers;
- develop sustainable incentives for farmers to accelerate adoption;
- strengthen farmer field schools and training centres; and
- advocate for supportive policies and regulations, such as tax incentives, investment support and infrastructure development.

The synergy between stakeholders in agriculture and the Kenyan government is vital for achieving food security and promoting the well-being of our farmers. Together they can implement innovative practices, build capacity and adopt sustainable technologies, while ensuring that no one is left behind, by focusing on improving agricultural productivity, enhancing resilience to climate change and ensuring the sustainable use of Kenya's precious natural resources.

7.3 Business model for women to access agricultural mechanization

Minli Yang
Professor, College of Engineering, China Agricultural University; Director, China Research Center for Agricultural Mechanization Development

Women make up on average 43 percent of the agricultural labour force in developing countries. The share is higher in some countries and varies greatly within countries. Although rural women have the same capacity for learning and enterprise, their potential in agricultural production has not been stimulated and their personal and career development needs cannot be effectively met. Most do not own or control any land.

China has implemented sound systems for legislation and regulation, management, scientific research, industrial development and extension of agricultural mechanization. Rural women are supported in mastering agricultural-mechanization technology, owning agricultural machinery and equipment, and developing agricultural production. Rural women have access to advanced and relevant agricultural machinery, and increased knowledge of their use, through the implementation of subsidy schemes to purchase agricultural machinery, the promotion of agricultural-mechanization technology and the organization of training and field day activities.

China's agricultural-mechanization development and hire-service business models (also called "socialized service" in China), have attracted increasing attention from developing countries. Chinese rural women with ideas, knowledge of technology and good management skills have actively engaged in the sector and developed three kinds of agricultural mechanization rental service business models.

Business model 1: Agricultural supply and marketing cooperatives provide a uniform supply of agricultural inputs, and purchase and sell agricultural products for smallholders, while agricultural mechanization cooperatives provide comprehensive mechanization rental services for smallholders. By offering a combination of supply and marketing with mechanization, agricultural cooperatives play an important role in leading smallholders towards sustainable agricultural development.

Business model 2: A new agricultural business entity targeting scattered small-scale farms provides centralized mechanized land-management or machinery-rental services. Rental services cover the whole agrifood value chain, including all steps of production, post-harvest, storage and processing. This can increase the added value of agricultural products and promote brand building. Market access through e-commerce (online) or an offline sales network can be developed. Integrating agriculture with mechanization and digitalization practices promotes the development of the agricultural industry and increases the resilience and sustainability of agrifood systems.

Business model 3: Is similar to business model 2 in providing agricultural inputs and sales of agricultural machinery, but also offers training for smallholders and provides information services as well. This business model features whole-process mechanization and an integrated agricultural service centre, allows smallholders to develop sustainably and promotes the development of the agricultural industry.

Women have great potential for development in modern agriculture. Rural women have gained economic benefits and improved their family status and social value while contributing to poverty reduction and food security using agricultural-mechanization technologies.

Governments should attach great importance to the role of rural women in the development of agricultural mechanization, and provide strong support for them to develop agricultural production and promote gender equality by intensifying their efforts in scientific and technological innovation, production and manufacturing, and policy support for agricultural mechanization.

7.4 Emerging mechanization business models

Hujjat Nadarajah
CEO, Tun Yat

This presentation explores an emerging business model that Tun Yat has introduced and has been gaining experience with, in the context of a dry-zone smallholder farming population in a delta in Southeast Asia. Tun Yat is a farming-service provider that operates a mechanization service and an input marketplace for a network of village development committees across Myanmar.

The emerging business model, developed over six years, is analysed using an organic development framework to see what actions arise to build a "Village Programme of Growth". These actions become more complex as they grow into a network of 40 villages, with a farming population of 100 000 farmers connected to a service centre coordinated by Tun Yat, to train and resource the area.

The development of the model was initiated with activities starting in 2017 working with the first 10 000 smallholder farming households and had grown in 2022 to include 47 000 households. For 2024, plans are underway to replicate the Village Programmes of Growth business model for adjoining areas and invite 100 000 more small-scale farming households into this learning process.

Innovation and insights also come from looking at how the technology roadmap and input marketplaces slowly bring in blockchains, commercial banks and corporate and donor financing to provide village committees with resources to finance mechanization and other input needs, using a revolving fund structure to catalyse capital for grassroots needs.

Parallel session: Multistakeholder engagement

7.5 Partnership for the development of agricultural mechanization

Marco Silvestri
Programme Officer, United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Centre for Sustainable Agricultural Mechanization (CSAM)

The Centre for Sustainable Agricultural Mechanization (CSAM) is a regional institution of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Its mandate is to promote the adoption of sustainable agricultural mechanization to achieve production gains, improved rural livelihoods and poverty alleviation for a more resilient, inclusive and sustainable Asia and the Pacific.

This mandate is directly linked to the achievement of SDG 1 and SDG 2, and contributes to SDG 13. Partnerships are the most effective way for CSAM to fulfil its regional mandate in all its dimensions: capacity building, research and advisory, and regional cooperation. CSAM serves 53 Member States in Asia and the Pacific. It leverages the intergovernmental platforms of ESCAP and its multistakeholder platforms, which are key for the development of partnerships with all stakeholders involved in agricultural mechanization.

CSAM focuses on small-scale farmers, which represent the majority of food producers in the region, and offers opportunities to link work with other regions. The agricultural mechanization policy models developed in the Asia and the Pacific region can be of interest to countries in Africa and Latin America. CSAM engages with intergovernmental bodies that build regional cooperation and integration at the subregional level, with regional commissions and platforms for joint projects, and with the Rome-based United Nations agencies for support to African participants in CSAM trainings.

CSAM annually convenes a regional forum to discuss the needs and solutions of sustainable agricultural mechanization with all stakeholders. These fora facilitated the development of successful initiatives and flagship projects on an inclusive, multistakeholder approach to develop sustainable agricultural mechanization in the region, as well as a wider implementation and outreach. These flagship initiatives are based on the establishment of partnerships with the participating institutions, that were recognized as "Good Practices in South–South and Triangular Cooperation" by the United Nations Office for South–South Cooperation, and include:

- ANTAM (Asian and Pacific Network for Testing of Agricultural Machinery) for the harmonization of testing regional standards of codes for small machinery, and to support the development of testing facilities in participating countries;
- ReCAMA (Regional Council of Agricultural Machinery Associations) for the involvement of the private sector and strengthening the capacity of national agricultural machinery associations, facilitating the exchange of knowledge and information, and enhancing collaboration and closer business connections for sustainable agricultural mechanization; and
- a regional pilot project on mechanization solutions for integrated management of straw residue that addresses the transboundary issue of straw-residue burning and its impacts on air pollution, human and soil health.

The Regional Forum also discussed the role of mechanization in climate-smart agriculture, support to food systems transformation to recover from the impacts of the COVID-19 pandemic, investment solutions for sustainable agricultural mechanization, and creating enabling environments for custom rental of machinery.

This year, the Forum will focus on closing the "gender yield gap", with the aim to develop partnerships to respond to this issue. The activities of CSAM demonstrate that the region and its subregions have a wealth of knowledge that needs to be scaled up and disseminated to improve food security.

7.6 Creating sustainable institutions and long-term vision frameworks

El Hassane Bourarach

Technical Adviser, Sustainable Agricultural Mechanization Pillar, African Conservation Tillage Network, Morocco

Sustainable agricultural mechanization in Africa is an urgent imperative and an indispensable pillar for attaining SDG 2, the Malabo Declaration commitment to ending hunger in Africa by 2025 and the African Union Agenda 2063: The Africa We Want. Doubling agricultural productivity and eliminating hunger and malnutrition in Africa by 2025 will not be realized unless mechanization along the food value chain is accorded the utmost priority.

The Africa Mechanize platform, supported by, among others, FAO, the AUC and the African Conservation Tillage Network, shows the way to establish a space for the development of sustainable agricultural mechanization at all geographic levels in Africa while encompassing the ten priority elements of F-SAMA. Between November 2019 and November 2022, during the COVID-19 pandemic, the platform played a key role in the organization of 11 webinars to operationalize F-SAMA. They brought together more than 1 600 participants (farmers, decision-makers, developers and experts) from 75 countries, with 75 speakers, to exchange on various themes relating to the technical, financial, socioeconomic and environmental aspects of sustainable agricultural mechanization. The webinars showed the richness of African experiences in the field of sustainable agricultural mechanization, such as innovative solutions for supplying mechanization through service-delivery platforms in several countries in the Great Lakes region and in southern Africa, and transformative approaches for the empowerment of young people and women through facilitating access to training and improving skills in several countries in southern Africa. The webinars also considered innovative financing mechanisms to increase smallholder farmers' access to mechanization services.

The webinars discussed the limited level and piecemeal deployment of mechanization due to the lack of a cohesive continental long-term vision as well as collected feedback from regional and continental experiences. Participants recommended sharing lessons learned to benefit from successful local and national innovations in sustainable agricultural mechanization, creating regional and continental synergies in decision-making support to implement sustainable agricultural mechanization strategies, increasing capacity building (governance, training and research) and venturing in joint search of regional, longer-term project funding.

Another ongoing achievement is the establishment of a network of DAMES in Africa dedicated to the exchange of information, data and experiences. To set Africa Mechanize on solid foundations, a pilot study of partners' needs in terms of information, technical assistance and exchange is currently underway in the Economic Community of West

African States as part of an R&D project by the World Bank and the African Conservation Tillage Network, together with other actors. Related research by the International Food Policy Research Institute (IFPRI) in Ghana also emphasizes the key role of national governments in creating an enabling environment for supporting private-sector-led supply models, which also involve small- and medium-scale farmers.

This presentation outlines the joint stakeholder efforts of the AUC, FAO, the African Conservation Tillage Network, DAMES from African countries and others in creating sustainable institutions and a long-term vision to implement F-SAMA. The success of these institutions is based on integration, inclusiveness, flexibility, good governance and mutual benefit, with human resources and funding as the main drivers.

7.7 Multistakeholder engagement for promoting growth of mechanization professionals and instilling public trust

Lawrence Gumbe
Chair of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE)

The objectives of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE) are to promote the application of the art and science of engineering to environmental, biological and agricultural systems, biology-based production and processing industries as well as to promote education, training and professional development of engineers in these relevant areas.

The African Union Agenda 2063 is similar to Kenya's Vision 2030, which aims to transform Kenya into a newly industrializing middle-income country providing a high quality of life to all its citizens in a clean and secure environment. The GDP per capita would increase from about USD 800 to over USD 10 000.

Industrialization is the process by which a country builds its capacity to process raw materials for consumption or further production. It involves the mechanization of manufacturing and an increase in the importance of manufacturing in the overall economy. Agricultural mechanization is a major pillar in the realization of Vision 2030 and Agenda 2063. Agricultural mechanization is a major production input that encompasses the application of engineering, mechanical technology and increased power to agriculture, largely to increase the productivity of land and human labour.

Engineers and other technical personnel are vital to the implementation of agricultural mechanization programmes and projects. There is a severe shortage of professional engineers in Kenya. KeSEBAE was created in 1972 and now has over 1 000 members. The membership categories are corporate, registered engineers and equivalent (with only 160 members); the rest are graduate and student engineers. The highest body of the organization is its general meeting, which elects the executive committee responsible for the management of KeSEBAE. The Society has vibrant regional, female and young engineers chapters.

The Society has effectively participated in the development and implementation of relevant degree and diploma curricula in universities and colleges, including the University of Nairobi, Egerton University, Kenyatta University, Moi University and the Technical University of Kenya.

In Kenya, practicing engineers, both Kenyan and non-national, are required by law to register with the

Engineers Board of Kenya. The registration provides assurance that engineers are adequately skilled to serve as engineers. A registered professional engineer is issued with a practising licence every year.

KeSEBAE has also been involved in on-the-job practical training of graduate engineers to become eligible for registration as professional engineers. KeSEBAE has also organized relevant continuous development courses, webinars, conferences, visits and other networking fora for engineers who are engaged in agricultural mechanization. To this end, KeSEBAE operates in a multistakeholder platform with organizations including the Engineers Board of Kenya, the Institution of Engineers of Kenya, the Association of Consulting Engineers of Kenya, the Pan African Society for Agricultural Engineering, the Kenya ministry for agriculture and livestock development, the Kenya Industrial Research Development Institute and the Kenya Agricultural and Livestock Research Organisation.

7.8 How to influence gender-sensitive policies in the domain of sustainable mechanization

Yamuna Ghale
Senior Research Fellow, Institute for Integrated Development

Agriculture contributes to 24 percent of Nepal's GDP, with 60 percent of Nepal's population deriving their income from the agriculture sector. Rural women make up 70 percent of the agriculture workforce, making a significant contribution to the national economy. Twenty-six percent of rural households are led by women.

A notable milestone for Nepal's agriculture sector is the constitutional provision of food security, the right to food and food sovereignty (Article 36), social justice and land reform (Article 51), under which the Right to Food and Food Sovereignty Act was proclaimed in 2018. These two legal arrangements pave the way for women's access to productive resources, inputs, technologies and benefit sharing.

Similarly, the Agriculture Policy (2004), the Agriculture Business Promotion Policy (2006), and the Agricultural Mechanization Promotion Policy (2014) also contain supportive provisions to promote the commercialization, industrialization, diversification and modernization of agriculture. These policies aim to support (disadvantaged) women and Dalit people to lead agricultural enterprises and to access, control and own gender-sensitive machinery and equipment. The goal is to reduce the cost of production, increase productivity and alleviate the workload and drudgery for women. The Prime Minister Agriculture Modernization Project is a showcase project that puts great emphasis on agricultural mechanization.

The migration of young males from rural areas to urban centres and abroad is an important fact in Nepal. This imposes on the remaining workforce, comprised mainly of women, the need to increase the productivity of land and labour, including through mechanization. Women therefore need better access to gender-sensitive inputs, production and post-production supplies.

There are constraints on both the demand and supply sides. These are related to land tenure and fragmentation, the untapped potential of women offering or seeking services in agricultural machinery, entrepreneurs' access to available machines and technologies, and lack of research and investments tailored to the needs, demands and priorities of women.

To ensure gender-responsive policies for sustainable agricultural mechanization that align with the national context, it is crucial to have adaptive, promotional and operational policies and strategies. These policies should be supported by operational guidelines and post-harvest standards to operate machines and be aligned with other related fields such as land, finance and research.

Attention is needed to: (1) recognize gender-sensitive needs and priorities throughout the value chain;
(2) prioritize responses to needs of women, young people and smallholder farmers; (3) challenge the discriminatory norms, institutions and practices that hinder women from accessing, operating and hiring mechanization services;
(4) support women's access to and control over machines and their influence on decision-making;
(5) provide options for types of businesses women would like to engage in, using management and operation service provisions and trading of machines; and (6) support the transformation of inequalities for sustained mechanization such as land tenures and user rights over productive land.

In short, there are certain policies and programmes that support gender sensitivity, but there are insufficient institutional mechanisms, investments and capacity to implement those policies for sustainable mechanization. The goal is to empower women to participate in decision-making and choose their roles to operate machines themselves, manage and mobilize services, and be part of the machine-trading chain for sustainable mechanization.

Chapter 8
Enabling environment

8.1 Enabling sustainable agricultural mechanization through farmer-led initiatives and collaboration

Arnold Puech d'Alissac
President, World Farmers Organization (WFO)

In addition to being food producers, farmers are also stewards of biodiversity and natural resources. They are economic actors in the agrifood value chain and are key drivers of rural development. By virtue and necessity, they are innovators who draw on knowledge and experience from the past to improve the way they farm while adapting to changing climate and societal needs.

To fully realize the potential of sustainable agricultural mechanization, farmers must be recognized as actors of change and partners in innovation. It is imperative to ensure that they are actively involved in the development of sustainable agricultural mechanization solutions from an early stage, ensuring that they can access the finance needed for investing in knowledge and technologies, and that they always have the right to choose the equipment and operations that best suit their needs. This will require developing relationships of trust across the various actors of the value chain and establishing new partnerships between farmers and providers on the ownership and management of the data and information created through mechanization processes.

8.2 Transforming agriculture in Africa: farmer-organization-driven strategies for an enabling environment in sustainable agricultural mechanization

Gerald Masila
Executive Director, Eastern Africa Grain Council (EACG)

Agriculture in Africa is dominated by small-scale farmers tilling small, fragmented pieces of land, using manual labour and rudimentary tools such as the handheld hoe. Mechanization is generally limited. The yield gap for most staples such as maize and beans has widened as production declines due to factors such as continued land subdivision, frequent crop failures exacerbated by climate change, pests and disease, and depleted and impoverished soils. Additionally, displacements, including those caused by conflict, make it difficult to transform agriculture in Africa.

The main grains produced and consumed in Africa are maize, wheat, rice, beans and pulses. African food imports continue to rise. Intra-African trade, driven by the difference in crop calendars and the ability for surplus-producing countries to trade with deficit countries, remains elusive due to a deficient road and transport network. Numerous policy challenges reflected in frequent unpredictable ad hoc tariff and non-tariff trade barriers are also a factor. However, the growing young population, the available arable land and intraregional trade provide great opportunities for the grain trade sector in Africa.

The Eastern Africa Grain Council (EAGC) is a regional not-for-profit, membership organization for grain value chain stakeholders whose members include grain farmers, grain traders, grain processors and millers, and other affiliated organizations such as services and solutions providers. Established in 2006, EAGC's mandate spans 10 countries in eastern Africa including Burundi, the Democratic Republic of the Congo, Ethiopia, Kenya, Malawi, Rwanda, South Sudan, Uganda, the United Republic of Tanzania and Zambia. EAGC has supported the development and implementation of strategies for an enabling environment for sustainable agricultural mechanization, including policy advocacy, provision of market information, training and capacity building and the development and implementation of structured grain-trading systems. EAGC support has allowed the selection of crop enterprises with a predictable, remunerative market price and a secure payment clearing and settlement mechanism, allowing for recovery and repayment of credit for mechanization.

However, high operational costs driven by the lack of economies at scale, poor governance of farmer groups and high energy costs continue to undermine efforts to provide mechanization.

Suitable policies that limit land subdivision and promote land consolidation to economical units are necessary to transform agriculture in Africa. To de-risk investments in mechanization, support for rules-based, predictable trade is essential. Removing taxation on agricultural mechanization and promoting contract farming to guarantee a market for the crops to repay the credit for mechanization are also crucial. Upskilling of agricultural-machinery operators, innovations and deployment of suitable technology complemented by ICT are vital. Provision of suitable financing, such as equipment lease finance and affordable renewable green energy for agricultural machinery and equipment, is also necessary.

8.3 Government role in enabling sustainable agricultural mechanization for economic growth and food sustainability in Zimbabwe: a case study

Edwin Zimunga
Chief Director, Agricultural Engineering, Mechanization and Soil Conservation

The presentation explored the Government of Zimbabwe's intervention in economic development through strategic interventions in agricultural mechanization. Agriculture forms the backbone of Zimbabwe's economy, with more than 67 percent of the population's livelihoods supported by agriculture. The government adopted policies that target agricultural mechanization to improve the production, productivity and competitiveness of the sector.

The country adopted a dual approach, based on policy and strategic investments, for its sustainable agricultural mechanization development agenda. From a policy perspective, government funding of mechanization represents 1.6 percent of the annual national budget. The government adopted the Malabo Declaration, committing 10 percent of the national budget to agriculture. The agricultural sector in Zimbabwe is consistently allocated over 13 percent of the national budget, out of which 15 percent goes to mechanization. From a strategic investment perspective, approximately 90 percent of the public funds allocated to mechanization go to strategic investments that are managed on a long-term cost-recovery basis and to revolving funds. The investments are either facilitated by the government or led by the private sector.

The Government of Zimbabwe has adopted inclusive mechanization facilities at an appropriate scale, considering the land tenure system and the size of farms, ranging from small-scale farms of just 0.1 ha to large commercial farms of more than 3 000 ha. From 2018 to 2023, Zimbabwe invested more than USD 600 million in agricultural mechanization facilities. These facilities and interventions are cross-cutting and varied in design, funding and beneficiary targeting. They cover seven of the GAMC thematic areas. There are practical and tangible cases of how the strategic investments and policy interventions ultimately led to recent successes in agricultural production in Zimbabwe.

In Zimbabwe, food security is now achieved, as also demonstrated by surplus production for grain cereals such as wheat, maize and traditional grains (sorghum, pearl millet and finger millet). The Zimbabwe Food and Nutrition Security Vulnerability Assessment study of 2023 reveals that Zimbabwe is now food secure. Nutrition security can now also be included as a target for the government's mechanization policies and strategic interventions.

Under the Zimbabwe Rural Development 8.0 Programming, Zimbabwe is targeting mechanization of fisheries through interventions such as cage culture and pond culture, and mechanization of small livestock (goats, pigs) and poultry production (chicken) through modern farm infrastructure, agroprocessing and cold-chain facility investments. The 8.0 Model seeks to industrialize rural farming to attain nutrition security at all levels.

The presentation shared examples of the key successes achieved in sustainable mechanization for which the Government of Zimbabwe played a major role.

8.4 Government role in enabling sustainable agricultural mechanization for economic growth and food sustainability in the Philippines: a case study

Rossana Marie C. Amongo
Dean, Agricultural Machinery Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines

Agriculture remains one of the pillars of the Philippine economy. The country's estimated total population in 2023 is 117 million, with a growth rate of 1.5 percent per year, making it imperative to find ways to increase the production of food, feed, fibre and energy sustainably. The use of agricultural and fisheries mechanization technologies is necessary to sustain these production systems in the face of a changing environment, advances in technology and changing ways of life.

The enactment and implementation of the Republic Act No. 10601 in 2013, promoting agricultural and fisheries mechanization in the Philippines, purposefully accelerated the acquisition, distribution and exploitation of agricultural and fisheries mechanization technology in rural areas. The Act is geared towards food sustainability and contributing to economic growth. This government initiative seeks to accelerate agricultural mechanization in the country through its various banner programmes, namely an agricultural machinery distribution programme, research support, development and extension, and support to local manufacturing of agricultural machinery. The goals of the Act are to provide farmers and fishers with access to appropriate and affordable agricultural and fishery machinery and equipment, to provide protection and support to agricultural and fishery machinery buyers, owners, manufacturers and distributors, and to strengthen support services and institutions for the development of the Philippines' agricultural and fisheries mechanization sector.

One of the major outputs of the Republic Act No. 10601 is the National Agricultural and Fisheries Mechanization Programme (NAFMP), which guides implementation of the activities provided for under the Act. The first NAFMP, from 2018 to 2022, was crafted and implemented with five components, namely: (1) local assembly and manufacture of agricultural and fishery machinery, (2) research, development and extension, (3) standards and regulations, (4) support services and institutional development, and (5) human resource development to complement the Act's implementation. The various programmes were implemented by the government through the Department of Agriculture as lead agency in collaboration with other national government agencies, local government agencies, academia and, most importantly, the private sector. The second NAFMP is set to be implemented from 2023 to 2028. In this phase, local agricultural and fisheries mechanization plans will be consolidated into a regional agricultural and fishery mechanization plan for the country.

Through the various mechanization programmes conducted since the Act came into force, the level of mechanization has increased, particularly in rice production systems, which increase from 2.31 hp/ha in 2013 to 3.77 hp/ha in 2021. The government is seeking to sustain and accelerate the pace of agricultural mechanization in the Philippines to promote economic growth and food sustainability in the country.

8.5 Fostering an enabling environment for sustainable agricultural mechanization from the perspective of supply-chain actors

Vanessa Stiffler-Claus
Vice President International Policy and Strategy, John Deere

Global agriculture is undergoing a rapid and beneficial transformation with the development of technologies that promote precision agriculture at all farm sizes. This innovation across the mechanization sector will enable greater productivity, sustainability and economic benefits for farmers globally. By leveraging public-, private- and NGO-sector expertise, we can support the adoption of technology across agriculture.

Precision agriculture transforms the efficiency of practices: precise planting maximizes field usage; precise spraying ensures only necessary input use – targeting field sections and even individual plants; machine guidance ensures field passes are synchronized; machine data collection plans for future field passes and maximizing yield. In short, precision agriculture does enable greater sustainability.

John Deere's focus on Africa is justified by the existence of a market for tractors of about 16 000 units. The mechanization adoption rate in Africa is now as low as 4 percent, yet about 60 to 70 percent of the population are involved in agriculture, varying by country.

John Deere has been present in Africa since 1962, with a regional headquarters in Johannesburg, South Africa, and a satellite office in Nairobi, Kenya, with sales and marketing personnel offering financial solutions, operating through authorized dealerships.

The **SMART** model developed by John Deer is defined as:

Solutions for small farmers/contractors;
Mechanization for higher yield;
Access to financing;
Reliability for lower costs; and
Technology and education.

John Deere supports a public–private partnership in Ethiopia, part of the Feed the Future Ethiopia Alliance to Accelerate Agriculture Growth. It leverages the diverse and unique skills of public, private and NGO sectors, brings modern technology to smallholders and creates a supportive ecosystem.

The objectives are to achieve: mechanization solutions for emerging farmers; increased productivity; improved profitability; empowerment for women and young people; and technical training.

So far, the public–private partnership has made it possible to: set up a certified training programme for operators; organize a training of trainers programme; establish more than six remote service centres in three major regions; deliver 30 tractors to the Tigray Region; organize a Deere/dealer tractor and combine optimization training; and, in partnership with Hello Tractor, outfit 130 tractors with kits to improve owner revenues.

8.6 Agricultural mechanization systems

Zhenxing Xu
Deputy Director, Centre of Agricultural Machinery Development and Extension, Ministry of Agriculture and Rural Affairs, China

Mengliang Bai
Senior Engineer, China Agricultural Mechanization Centre, Ministry of Agriculture and Rural Affairs, Beijing, China

China is a large agricultural country, with a population of over 1.4 billion people. The basic situation in China is that there are hundreds of millions of small farmers with only 0.087 ha of farmland. China has a total farmland of 120 million ha, so the per capita use of farmland in China is thus less than half the world average. Annual yields in China reach 630 million tonnes for grains and about 700 million tonnes of fruit and vegetables. With access to 7 percent of the world's arable land, China produces one quarter of the world's food and feeds one fifth of the world's population. Policies and access to technology, especially mechanization, play a key role in this achievement. Three main types of production are at present practiced in China, including small farmers, moderate-scale operations and leading enterprises, representing respectively about 70 percent, 25 percent and 5 percent of the total farmland in China.

To develop agriculture, the Chinese Government has paid attention to mechanization systems. The total amount of agricultural machinery continues to grow. At the end of 2022, the total output of agricultural machinery reached 1.1 billion kilowatts. There were 1 776 scaled agricultural machinery manufacturers in China, with a business revenue of CNY 286 661 billion (USD 39 billion). By 2021, the comprehensive mechanization level that covers ploughing, sowing and harvesting was up to 72 percent. The number of farmer cooperatives that promote the application of advanced agricultural technology and equipment and organize small farmers to be part of the agricultural value chain is increasing. Support services are implemented along the entire value chain, including processing and transport.

Measures taken to improve agricultural mechanization systems in China include: (1) taking full advantage of laws and policies, such as purchase subsidies and application subsidies; (2) integration of agricultural machinery and agronomy with the combination of good machines and good methods, seeds and good governance; (3) promoting the connection between small-scale farmers and modern agriculture, developing various forms of appropriate-scale operation while protecting the rights and interests of small-scale farmers; (4) encouraging land circulation from small-scale farmers to agricultural professional cooperatives or agricultural companies voluntarily; (5) leading production hosting services, serving more than 70 million small-scale farmers at present in China; and (6) promoting innovative technologies through experimental demonstration, interface platforms, production operation assessment and online and offline training.

Sustainable agricultural mechanization systems have played an important role in the achievement of agricultural production in China. Policies suited to national conditions will promote the development of sustainable agricultural mechanization systems. By taking these measures, China will further improve agricultural mechanization systems to contribute to sustainable agricultural development.

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Chapter 9
High-level ministerial segment and closing plenary session

9.1 Statement

H.E. Mohan Priyadarshana De Silva
Honourable State Minister of Agriculture, Sri Lanka

Ladies and gentlemen, distinguished guests, and fellow advocates of sustainable agriculture,

It is a great pleasure and privilege for me to address this esteemed global conference on sustainable agricultural mechanization as the State Minister of Agriculture for Sri Lanka.

I would like to thank FAO for inviting me to this special occasion to represent Sri Lanka, which is a country with great agricultural potential. I would also like to thank you for selecting as the conference theme "Efficiency, Inclusiveness and Resilience", which is timely and important in achieving the Sustainable Development Goals of the United Nations 2030 Agenda.

Ladies and gentlemen, dear friends,

During the COVID-19 pandemic, and post-COVID economic crisis, FAO provided crucial support to Sri Lanka by assisting in the development of strategies to ensure food security and nutrition for vulnerable populations. This support included technical expertise, chemical-fertilizer grants in agriculture production and supply-chain management to minimize disruptions in food distribution. Additionally, FAO collaborated with local partners to promote sustainable farming practices and increase the resilience of Sri Lanka's agriculture sector in the face of the pandemic's challenges. I extend my heartiest gratitude to FAO for its invaluable support to Sri Lanka during these challenging times.

Sri Lanka, with its rich agricultural heritage, is at the crossroads of transformation. We find ourselves at a pivotal moment where the choices we make today will profoundly influence the future of our agriculture, our environment and the livelihoods of our farmers. In this speech, I wish to focus on three critical aspects: policies, initiatives and financial investments, all geared towards promoting innovative, efficient, resilient and sustainable agricultural mechanization in Sri Lanka.

1. Innovative policies

The cornerstone of our vision for sustainable agricultural mechanization lies in the development and implementation of innovative policies. These policies will serve as the guiding light to navigate the challenges and seize the opportunities that lie ahead.

a. Regulatory frameworks: Sri Lanka is committed to creating a robust regulatory framework that encourages the adoption of advanced agricultural technologies while safeguarding our environment and ensuring equitable benefits for all stakeholders. We will strive for policies that promote responsible mechanization, recognizing that sustainability and innovation must go hand in hand.

b. Research and development: the government is actively investing in research and development initiatives to identify and promote technologies that are tailored to our unique agricultural landscape. This includes supporting local research institutions and fostering partnerships with international experts to accelerate technological advancements.

c. Data-driven agriculture: we acknowledge the power of data in making informed decisions. Our policies will emphasize the importance of data-driven agriculture, promoting the use of precision farming techniques, and leveraging big data and artificial intelligence to optimize crop yields while minimizing resource use.

2. Initiatives for capacity building

Building the capacity of our farmers and agricultural workforce is a fundamental aspect of our sustainable mechanization strategy, as follows:

a. Training programmes: we are committed to launching comprehensive training programmes that equip our farmers and workers with the skills needed to operate modern machinery safely and efficiently. These programmes will prioritize sustainable practices, safety and the responsible use of resources.

b. Farmers' cooperatives: we recognize the strength in unity. Our government will encourage the formation of farmers' cooperatives to facilitate collective access to mechanization services, thereby reducing the burden on individual farmers and promoting resource-efficient practices.

c. Technology transfer: Sri Lanka is eager to foster partnerships with nations and organizations that can help us transfer cutting-edge agricultural technologies to our farmers. We believe in the power of knowledge exchanges to drive progress.

3. Financial investments

Financial investments are the lifeblood of our vision for sustainable mechanization. Without adequate resources, our dreams remain unrealized. Thus, our government has taken the following steps to overcome the situation:

a. Access to affordable financing: our government is actively working with financial institutions to develop accessible and affordable financing solutions tailored to the needs of our agricultural sector. We recognize that affordability is key to widespread mechanization adoption.

b. Public–private partnerships: we welcome collaborations with the private sector to mobilize financial resources and expertise for the development of sustainable mechanization. Together, we can create win–win scenarios that benefit both farmers and investors.

c. Investment in infrastructure: infrastructure development, including rural roads and storage facilities, is essential for the success of mechanization efforts. We are committed to making strategic investments in infrastructure to support our farmers and ensure efficient supply chains.

In conclusion, Sri Lanka envisions a future where our agriculture is not only innovative and efficient but also resilient and sustainable. We understand that this transformation is a shared responsibility, and we are eager to collaborate with our global partners in this journey.

Let us remember that sustainable agriculture is not just about increasing yields; it is about safeguarding our environment, improving livelihoods and ensuring food security for generations to come.

Together, with the right policies, initiatives and financial investments, we can turn this vision into a reality, not only for my country but for the entire world.

Thank you for your attention, and I look forward to productive discussions and collaborative efforts during this conference. Together, we can cultivate a brighter and more sustainable future for agriculture.

Finally, I wish to thank FAO and its officials for organizing this very fruitful international conference.

9.2 Statement

Ms Renata Bueno Miranda
Secretary of Innovation, Sustainable Development, Irrigation and Cooperativism, Ministry of Agriculture and Livestock, Brazil

Director-General QU Dongyu,
Deputy Director-General Beth Bechdol,
Authorities, Scientists, Delegates, Ladies and Gentlemen,

Understanding territories and their different production environments is vital to tailoring enabling strategies and mechanisms for successful sustainable agricultural mechanization and digitalization.

For each region, we have different environmental, technological and – we have to say – cultural challenges.

I will summarize the many possibilities in four examples of important strategies that push mechanization transformation towards efficient and sustainable agriculture in Brazil.

The first example is financing through our governmental programme called the Harvesting Plan. Through it, farmers can access rural credit for the implementation of sustainable practices and technologies. Among others, this programme enables the adoption of machinery customized for the use of no-till systems in over 40 million ha dedicated to soybean production nationwide.

The second one is innovation. Investment strategies in research and technical assistance are vital. For example, irrigation technologies are changing lives in the northeast of Brazil. This very hot and dry semiarid region, where two decades ago nobody could thrive, has become an oasis of fruit production. Nowadays, the San Francisco River Valley is one of the leading areas for the production and export of fruit, generating jobs, income and better livelihoods.

The third strategy is fostering cooperativism, especially among smallholders to overcome the challenges related to fragmented production.

And finally, the fourth example is connectivity and digital services. Connectivity remains the main challenge to upscale sustainable digital agriculture in Brazil. Today, only 28 percent of rural properties in the country have access to the internet. Projections suggest that bringing connectivity to 50 percent of Brazilian farms would increase national gross production value by about USD 10 billion.

Together, these four examples of important strategies show what is needed to enable a favourable environment to upscale digitalization and mechanization as powerful instruments in sustainable agricultural transformation. Finally, the integration of public policies, private companies and farmers is key to assure food security in the present and future.

9.3 Statement

Mr Alpisbay Tolibaev
Head of Department, Doctor of Technical Sciences, Ministry of Agriculture, Uzbekistan

Dr QU Dongyu,

Participants of the Global Conference,

I am very pleased to participate in the first global conference on sustainable agricultural mechanization organized by FAO.

With your permission, I would like to present on the reforms being carried out in the agricultural sector in Uzbekistan, and discuss the prospects for the development of sustainable mechanization of agriculture.

We are now in a period of historic change in terms of the diversification and transformation of agriculture in Uzbekistan and the development of a modern management system.

The "Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020–2030", adopted by our respected President in 2019, sets out programme objectives to be implemented in the field.

The Strategy identifies nine important priority areas for industrial development. Between 2019 and 2022, several results were achieved in these areas. To develop a modern public administration system, the Ministry of Agriculture adopted a unified policy to manage the agrifood sector.

The Agricultural Knowledge and Innovation System was launched with the aim of developing a system of science, education, information and advisory services in agriculture and providing services to farmers. Agricultural Knowledge and Innovation Systems were established in 13 regions of the country.

At the same time, the Research Institute of Agricultural Mechanization played an increasingly prominent role.

The Institute has implemented more than 100 projects, which is important in ensuring that mechanization services are of a high quality. Increasing the volume of agricultural crops in Uzbekistan, obtaining high yields, reducing consumption costs and increasing soil fertility naturally depend on the level of mechanization.

Scientists and mechanical engineers thus play a special role in achieving sustainable mechanization.

Fruit and vegetable areas have increased by 470 000 ha, including 75 000 ha of intensive gardens and vineyards and 3 700 ha of modern greenhouses. Production of fruits and vegetables increased by 20 percent and reached 22.5 million tonnes.

Grain yields increased from 5.7 tonnes to 7 tonnes per hectare. Agriculture grew by an average of five percent per year, with the level of mechanization certainly playing a big role in these figures.

In the Global Food Security Index, Uzbekistan's standing rose by 12 places among 113 countries, and was first among the 10 countries with the highest rates of growth.

Agro-clusters and cooperatives – new mechanisms for economic management – have been established, with integrated "science, technology and innovation" systems. Today, 833 agricultural agro-clusters and more than 200 cooperatives have been launched.

With the introduction of innovations and modern agricultural technology and mechanization in cotton agro-clusters in 2022, yields increased from 29 t/ha to 3.4 t/ha.

It is estimated that 268 000 items of agricultural equipment are in use today, representing 80 percent of the need for equipment to support agricultural production.

Over the past five years, farmers and agro-clusters have purchased more than 53 000 units of modern resource-saving equipment. As a result, between 8 to 10 percent of the equipment fleet was renewed annually.

Over the past three years, around one thousand laser levellers have been purchased, and 650 000 ha of land have been levelled.

As a result of these systemic reforms, the sowing season was shortened from 15 days to 10 days, the grain-harvesting season was shortened from 30 days to 20 days, and it became possible to complete ploughing in 25 to 30 days.

In cotton and grain growing, the provision of equipment is more than 90 percent; in horticulture, viticulture, livestock and vegetable growing, it is slightly lower.

Therefore, several projects were subsequently developed to improve leasing services for agricultural machinery to increase the supply of equipment and improve mechanization services in these areas.

Consequently, the level of mechanization in horticulture will increase by 65 percent, in vegetable growing by 67 percent and in livestock farming by 70 percent.

To increase the levels of mechanization, the government currently offers the following incentives:

- currently, subsidies of 15 percent of the equipment cost are available for all domestically manufactured agricultural equipment;
- 30 percent of the total cost will be reimbursed from the national budget to agricultural producers that purchase a laser leveller;
- when leasing or purchasing agricultural machinery on credit, more than 10 percent of the interest costs are covered by the national budget;
- all types of agricultural machinery, as well as their components and spare parts, imported by agricultural enterprises and business entities are exceptionally exempt from customs duties (value added tax, except for customs clearance fees) and from the recycling fee until 1 January 2025;
- payment of the value added tax on agricultural machinery can be deferred up to 270 days; and
- 30 percent of the operational costs of cotton-picking machines of agricultural producers in Jizzakh, Kashkadarya, Syrdarya and Tashkent regions are reimbursed by the State.

At the same time, to increase the level of agricultural mechanization from 2022 to 2026, the following measures have been set out:

- increasing the rate of renewal of the agricultural machinery fleet;
- further improving the types and volumes of local services provided, the warranty period for agricultural machinery and services, and the supply of spare parts in subsequent periods; and
- systematically introducing training and retraining of engineers for the maintenance and repair of high-performance agricultural machinery.

During this global conference, I have gathered a lot of useful information on agricultural machinery and services that support sustainable agricultural mechanization intended for small- and medium-sized farmers, as well as on how to increase crop yields.

I believe this global conference has served as a neutral forum for farmers, researchers, the private sector, manufacturers and industry representatives working towards sustainable agricultural mechanization.

Thank you for your attention.

9.4 Statement

Mr Eric Renaud
Director-General of the National Society of Agricultural Mechanization (SoNaMA), Benin

Between 2016 and 2021, Benin began the modernization of agriculture to increase both yields and its contribution to the creation of national wealth and employment. Harvests of cash crops intended for export as well as food crops are constantly improving. This is how Benin has become, since the 2018–2019 campaign, the leading cotton producer in Africa. Benin also stood out as the second producer of food crops in the West African Economic and Monetary Union in 2019. The same upward trend is observed in the livestock and fishing subsectors, which will experience a boom in the years to come. To achieve this, the reforms consisted of:

- establishing a new institutional framework with the creation of seven agricultural development poles;
- disengaging the State from the agricultural production sector;
- rehabilitating the cotton interprofessional sector;
- facilitating access to seeds, inputs and markets for the promotion of new agricultural sectors (rice, corn, cashew nut, pineapple, soybean, sheanut);
- facilitating access for agricultural entrepreneurs to appropriate financing through the National Agricultural Development Fund;
- cleaning bodies of water by ridding them of all prohibited fishing gear;
- improving livestock production systems through the introduction of small ruminant breeders and local chickens, as well as through the promotion of artificial insemination; and
- developing agricultural mechanization with an endowment fund of USD 16 million to finance the acquisition by producers of machines, equipment and spare parts.

Massive investments of around USD 985 million were made during the 2016–2021 period to support the sector. This contributed to the very good performance of high-added-value sectors (pineapple, cashew nuts, market gardening), conventional sectors (corn, rice, cassava), animal and fisheries sectors, as well as so-called emerging crops (soybean, sheanut). In fact, our country is increasingly positioning itself as a regional agricultural power.

To consolidate our performance with a view to promoting, on the one hand, food self-sufficiency and cash production and, on the other hand, a greater transformation of agricultural production, our 2021–2026 actions consist of, in particular:

- accelerating agricultural mechanization by facilitating producers' access to financing;
- promoting farming techniques and practices that are resilient to climate change;
- establishing a private service and training ecosystem for the benefit of agricultural producers; and
- promoting the industrial transformation of agricultural production with equipment made in Benin to encourage job creation in the sector.

Drawing on the lessons learned from the various experiences of developing mechanized and irrigated crops, both at the initiative of the State and that of the private sector, the concern for efficiency led Benin to entrust in 2021 the implementation of the National Agricultural Mechanization Development Programme, and small-scale irrigation under the National Irrigation Development Programme, to the National Agricultural Mechanization Company (SoNaMA).

SoNaMA has two development objectives:

- to promote the rational use of agricultural materials and equipment with a view to reducing the drudgery of work and contributing to the increase in agricultural

production and, consequently, to economic growth and the reduction of poverty; and
- to improve agricultural production and the resilience of the agricultural sector to climate change.

To achieve these objectives, SoNaMA based its action on three components:

- Agricultural: the development of soil-conservation agricultural techniques to preserve soil capital.
- Industrial: the development of a local agricultural equipment industry, allowing the local manufacturing of all the equipment necessary for value chains.
- Social: improving the life cycle of agricultural equipment, making it possible to generate a financial contribution during the renewal of equipment and the development of a second-hand market for buyers who have less capital.

Implementing the various mechanization actions will make it possible to quadruple the driving power made available to agriculture for pre- but also post-harvest operations, increasing it from 124 081 hp to 560 000 hp and to sustainably create by 2026 new work opportunities such as the manufacturing, repair and aftersales service of agricultural machinery. It will also make it possible to reduce the drudgery of work and generate gains in productivity and production for various agricultural crops while preserving soils.

9.5 Closing

QU Dongyu
FAO Director-General

Excellencies,
Ladies and Gentlemen,
Dear Colleagues,

As we come to the close of this historic Global Conference, I know that our time together does not end here.

Over these past three days, we have shared ideas and solutions that will help us shape the future of agriculture.

We have built an even stronger network – of more than 8 000 people – to drive sustainable agricultural mechanization, to drive innovation and to drive transformation.

We have agreed and committed to working together to contribute to building a better world, for generations to come.

Starting with the transformation of global agrifood systems.

Through the use of equipment and technologies, we are already transforming how we produce, harvest, store, process and distribute our food.

But we need to continue pushing the boundaries of what is possible in agrifood systems.

And, in all our efforts, we must ensure that we do not leave anyone behind.

We need to make equipment and technologies more accessible, affordable, safe and appropriate for all, especially smallholder farmers.

Throughout this conference, we spoke about the challenges and opportunities for sustainable agricultural mechanization.

We agreed that we need to have:

the right policies in place,

the right support systems, access to spare parts, to financing and to business models that promote inclusive participation of all partners.

But above all, we all agree that to realize the full potential of sustainable agricultural mechanization, we need to work together.

This conference leaves an important legacy because it gave a voice to everyone: policymakers, farmer organizations, the scientific community, the private sector, civil society, opinion leaders and, most importantly, to young people.

Through sustainable agricultural mechanization, we are changing how farming and agriculture is perceived – making this sector more attractive to young people.

Young people are the future of agriculture.

For this reason, I recently created the FAO Office for Youth and Women – to advocate for inclusivity, prioritize their involvement and recognize their contributions to agriculture.

I would like to highlight four key points that we can take away from this milestone conference:

First, farmers.

Solutions must be prepared for farmers, with farmers and by farmers, because they are on the frontlines and are the first and most impacted by the climate crisis, plant pest and diseases, antimicrobial resistance and other threats.

Second, new and emerging technologies.

The private sector plays a key role in driving development, but it must be sustainable, economically viable, affordable and accessible to all.

Third, enabling policies.

We need policies underpinned by scientific advances and evidence-based decision-making.

And fourth, strategic partnerships.

Together, we can mobilize knowledge, resources and innovations, and identify and develop evidence-based solutions.

In addition, the 15 forward-looking actions you have identified aim to drive real change, challenge how we work and advocate for further developing sustainable agriculture mechanization.

As we close this conference, let us not lose the momentum, but build on it.

Mechanization, digitalization and industrialization must continue to be at the core of our discussions, because they are the foundations for building a better future, where we produce more with less – for a more food-secure future for all.

FAO will continue working with all of you to achieve the transformation of agrifood systems to be more efficient, more inclusive, more resilient and more sustainable.

Let us work together to create a future where sustainable agricultural mechanization, digitalization and industrialization fully supports the four betters: better production, better nutrition, a better environment and a better life – leaving no one behind!

Thank you.

Chapter 10
Conference call to action

Introduction

The Global Conference on Sustainable Agricultural Mechanization (GAMC) with the theme "Innovation, Efficiency and Resilience" was convened at the Food and Agriculture Organization of the United Nations (FAO) headquarters in Rome from 27 to 29 September 2023.

Participation

The GAMC attracted the interest of over 5 600 online viewers and over 300 attendees in person. Of the registrations, 50 FAO Members registered to the event. Most registrations came from Africa (39 percent); the second-largest group was from Asia and the Pacific (29 percent). The discussions highlight the contributions and benefits stemming from the sustainable development of agricultural mechanization, showcasing current and emerging technological developments and related business models, supply chain aspects, agricultural machinery standards and the overall enabling environment for sustainable agricultural mechanization. Deliberations were organized in seven thematic sessions across the three-day event. The call to action below are in line with the implementation of the FAO Strategic Framework 2022–2031 and contribute to the achievement of the Sustainable Development Goals.

As FAO, we commit to continue to:

- Provide technical support at country, regional and global levels through our existing channels, but to also be able to work with all of you to explore new channels and working modalities.
- Encourage, lead and convene more of these policy dialogues.
- Support countries and national governments in developing and implementing national policies, regulations and laws that support sustainable development of agricultural mechanization.
- Facilitate the establishment and operation of effective mechanisms including a multistakeholder global technical panel to oversee the implementation of the conference call to action and address the evolving needs and issues related to sustainable agricultural mechanization – and supported by FAO.

FAO Members are invited to consider the following call to action.

Mechanization for crop production

1. Increase access to farm power for farmers, appropriate to the scales and circumstances of local conditions through a variety of business models (including service-provider models) and financing

schemes, to reduce drudgery and to increase food security without degrading natural resources.

2. Invest in and promote precision technologies for crop production including protected cultivation, especially for small-scale farming systems.

Post-harvest and agroprocessing

3. Establish post-harvest supply chain joint ventures in affordable, high-tech, structural and mechanical designs, and logistics systems combined with quality monitoring, prediction and control methods towards a zero-waste fresh food chain.
4. Encourage sustainable quality-control practices within agroprocessing operations, with efficient energy, water and waste management to make affordable and consumer-trusted healthy processed foods ensuring food security. Provide technology transfer and innovation to increase circular bioeconomy practices for a sustainable agrifood chain that reaches all populations, leaving no one behind.

Climate change and resilience

5. Incentivize climate-smart, conservation and precision agriculture type mechanization and management systems through comprehensive policies that are explicit and sensitive to climate change mitigation and adaptation, and disincentivize soil- and environment-degrading practices. This should include increased training or support of extension agencies, and financing incentives or targeted priority programmes for institutions.
6. Rate farming equipment and related systems (starting from manual and draught-animal power systems) and their management options in terms of emissions reduction and natural-resource protection. Score agricultural practices relative to, for instance, conservation agriculture, quantitatively for greenhouse gas emissions and protection of natural resources and biodiversity.

Digitalization and automation

7. Commit to developing technologies tailored to the needs of smallholder farmers, enhancing their digital skills. Prioritize training and support for both farmers and service providers in making sustainable data-driven decisions. Establish a robust digital infrastructure that ensures open and equitable access, as a catalyst for the sustainable increase of agricultural productivity.
8. Pledge to amplify research and demonstration in automation and artificial intelligence, seamlessly integrating them into sustainable agrifood chains. Champion the growth of start-up ecosystems and innovative business models, particularly for small farmers and regions with lower incomes, to fast-track advancements in sustainable agricultural mechanization.

Supply chain and standards

9. Strengthen the supply chains for agricultural machinery, equipment and implements in developing countries by incentivizing/attracting suppliers and agribusiness to optimally use the capacity of local dealers and franchises as well as manufacturers to ensure the competitive and continuous provision of services, including capacity development for operators and aftersales services.
10. Encourage the development and harmonization of standards, test protocols, certifications and data for agricultural machinery to facilitate the trade of safe and well-performing machinery. Facilitate the development and establishment of subregional and regional protocols for testing and certification of agricultural machinery, including for gender-inclusive design.

Business models and multistakeholder engagement

11. Increase business opportunities through comprehensive policies, programmes and institutional collaboration to incentivize, educate and enable farmers and entrepreneurs to develop capacity for local and national levels, meeting mechanization and service-provider needs.
12. Promote innovative and inclusive business models along the value chain with the involvement of farmers, financing institutions, small- and medium-scale entrepreneurs, business owners and others to foster entrepreneurship in providing access to mechanization services.

Enabling environment

13. Strengthen national and international institutions to explicitly provide coordination and advice on sustainable agricultural mechanization and digitalization to the government and other stakeholders, ensuring representation by key public and private stakeholders.
14. Create an enabling business environment to make mechanization services more accessible, available, affordable and timely to all farmers through commercially viable enterprises.
15. Attract young people to work and innovate on mechanization and digitalization by creating entrepreneurship incubators, facilitating finance and subsidies, investing in mentorship programmes and enhancing their skills.

Governments, development partners and all stakeholders are called upon to implement these call to action, publicize them widely through appropriate electronic and print media, incorporate them into advocacy materials and provide feedback to FAO.

For further information and engagement, please contact the Director of the FAO Plant Production and Protection Division: **NSP-Director@fao.org**.

Annex 1
Joint machinery and livestock exhibition, 25 to 29 September 2023

Agricultural Machinery Exhibition Report

Introduction

On the occasion of the FAO Global Conference on Sustainable Livestock Transformation (GCSLT) hosted by FAO from 25 to 27 September 2023 and the Global Conference on Sustainable Agricultural Mechanization (GAMC) hosted by FAO from 27 to 29 September 2023, a Joint Agricultural Machinery and Livestock Exhibition was organized at FAO headquarters in Rome, from 25 to 29 September 2023. The overall objective of the exhibition was to showcase innovative solutions, approaches and cutting-edge technological paths for the future addressing economic, social and environmental challenges within agrifood value chains for both livestock and plant production, highlighting interactions between both sectors. The agricultural mechanization segment of the exhibition was centred around the theme of "Sustainable agricultural mechanization: technological paths to a better future".

More precisely, the exhibition aimed to:

1. foster awareness regarding the sustainable advance of agricultural mechanization and the promotion of sustainable practices;
2. showcase the strides made in sustainable agricultural mechanization in response to the considerable challenges posed by sustainable food systems; and
3. educate visitors and conference attendees about innovative solutions and technologies for sustainable agricultural mechanization, emphasizing the pivotal role played by the private sector in developing and providing agricultural equipment.

The exhibition was held on FAO premises, in the Atrium, the Flag Hall and the outdoor parking areas. The logical layout of the exhibition was designed to encourage active engagement with the displayed technologies by visitors and conference participants. The exhibition also incorporated visual and graphic elements that reinforced the overarching message aligned with the conference themes.

The event showcased the latest advances in agricultural mechanization across the agrifood value chain, alongside conventional farming equipment that has addressed economic, social and environmental challenges. Conference participants had the opportunity to experience mechanization in practice, witnessing cutting-edge technologies and their positive impact on farming communities and the environment. They also recognized the progress in sustainable agricultural mechanization, the efforts to establish sustainable agrifood systems, and the innovative solutions and high-quality agricultural equipment developed by private-sector partners.

Inauguration of the Joint Exhibition Agricultural Machinery and Livestock Exhibition

Dr QU Dongyu, FAO Director-General, inaugurated the Joint Agricultural Machinery and Livestock Exhibition on 26 September 2023, accompanied by Beth Bechdol and Maria Helena Semedo, FAO Deputy Directors-General, Alessandro Malavolti, Vice-President of the European Agricultural Machinery Association (CEMA) and Altantuya Tseden-Ish, Chair of the Asian Farmers' Association for Sustainable Rural Development (AFA) and President of the National Association of Mongolian Agricultural Cooperatives.

The event was attended by a diverse audience of more than 100 participants, including senior policymakers, representatives from various countries and regions, farmer organizations, members of the scientific community, national agricultural education, research and extension systems, development organizations, the private sector (comprising selected mechanization service providers, practitioners and farm-power suppliers), international finance institutions, donor agencies, civil society, opinion leaders and grassroots organizations.

During his opening address, the Director-General emphasized that over 50 years ago, there was a significant debate about the necessity of agricultural mechanization. In his view, this debate impeded progress. He stressed that it is now evident that agriculture relies on scientific advancements, machinery, equipment, soil and water management, and the protection of animals. He also emphasized the importance of having all the essential modern components in place to achieve increased and improved agricultural productivity with greater efficiency. He pointed out that "we require evidence-based solutions and innovations, and we require action".

The Director-General noted that the conference and exhibition served as an inclusive platform for governments, the private sector, academia, the general public, civil society and farmers to effectively translate words into action and realize the complete implementation of the Sustainable Development Goals (SDGs) on a practical level. These sentiments were echoed by Deputy Director-General Beth Bechdol and Mr Alessandro Malavolti in their speeches at the inauguration ceremony. Additionally, Ms Altantuya Tseden-Ish concurred that "we need solutions and innovations to make livestock production system".

The exhibition brought together over 20 diverse private-sector organizations, start-ups and a CGIAR centre to effectively showcase how mechanization can significantly improve production, optimize resource utilization and minimize environmental impact. The exhibition featured a wide array of equipment, including electric tractors, combine harvesters, drones and weeding robots, which came from 13 different countries across Asia, the Southwest Pacific, Africa, Latin America and North America. Additionally, the exhibition showcased equipment and machinery that are currently in use in projects across sub-Saharan Africa.

Inauguration of the Joint Exhibition Agricultural Machinery and Livestock Exhibition

The exhibition took place in indoor (Atrium and Flag Hall) and outdoor locations (Building A and Aventino parking). It featured a diverse array of exhibits, encompassing conventional equipment, innovations tailored for small-scale farming, precision agriculture technologies, automation and agricultural robots.

These displays highlighted the latest technological advances in agricultural mechanization and digitalization, with the potential for customization to meet the unique needs of small-scale farmers in developing countries. The table below provides a summary of the machinery, equipment and implements exhibited.

List of machinery and equipment exhibited at GAMC 2023

Disclaimer: The selection of the participating entities acting as exhibitors did not represent any endorsement, sponsorship or favouring on the part of FAO. Similarly, any references to a specific commercial product, process or service displayed during the exhibition were for the information and convenience of the exhibition only and did not constitute any endorsement, sponsorship or favouring by FAO. FAO did not represent or endorse the accuracy or reliability of any information, product or equipment presented by the exhibitors.

Precision planting liquid stand

Precision Planter (AGCO) optimizes row-crop fertility through precise nutrient placement, improving yield potential by facilitating efficient nutrient uptake. The FurrowJet system ensures timely access to essential nutrients for the developing roots, preventing deficiencies. The Conceal attachment discretely deposits nutrients 7 cm away from the seed, within the row-unit, to support early plant growth.

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Massey Ferguson S Series tractor

Multitask tractors (Massey Ferguson/AGCO Corporation) are highly versatile machines capable of a wide range of field applications, including harvesting, ploughing, seeding, fertilizing, and spraying. Additionally, they serve as efficient loaders due to their excellent visibility. These tractors are also suitable for heavy trailer transport on the road. Massey Ferguson Multitask tractors come equipped with advanced technology features, including precise guidance, section control, rate control, connectivity, and telemetry. The ISOBUS system enables seamless communication with attached implements, while the Datatronic 5 touchscreen provides intuitive control and monitoring of all tractor functions.

©FAO/Godfrey Omulo

Round baler

Round baler (Massey Ferguson/ AGCO Corporation) offers variable bale diameters to accommodate customer preferences and crop selection. The adjustable pick-up speeds crop transfer to the cutter, efficiently cutting the material to increase bale feeding value. Bales can be securely bound using net, twine, or film as per specifications. The ISOBUS system enables easy setup, control, and management through the tractor's monitor, while the baler automatically records performance metrics, including bale number, moisture, and weight, and compares each result to the field's average.

©FAO/Godfrey Omulo

Manual seeder

The manual seeder (Bassi Seminatrici srl) is an innovative, hand-operated tool for precise and efficient sowing of various crops. It offers practical versatility to improve agricultural practices and crop productivity.

©FAO/Francisco Martinez

10.5 hp two-wheel tractor

The 740 PowerSafe® two-wheel tractor (BCS S.p.A.) is a robust, professional two-wheel tractor designed for various intensive tasks such as gardening, landscaping, snow removal, and maintenance of vineyards and orchards.

©FAO/Francisco Martinez

8.5 hp two-wheel tractor

The 738 PowerSafe® two-wheel tractor (BCS S.p.A.) is a professional two-wheel tractor designed for farming and demanding tasks such as soil preparation, vineyard maintenance, orchard care, snow removal, and large garden maintenance.

©FAO/Francisco Martinez

Rotary hoe

The rotary hoe (BCS S.p.A.), used with a precision depth roller, precisely tills the soil for seeding, buries plant residues, removes weeds, and compacts the surface layer. It is compatible with 66 cm- and 80 cm-wide rotary hoes.

©FAO/Francisco Martinez

Two-wheel tractor seed drill

The compact seed drill (CIMMYT) for maize and beans is designed for intercropping and relay planting, making it suitable for low-horsepower two-wheel tractors, especially on uneven terrain.

©CIMMYT/Joshua Patiño

Hand-operated fertilizer spreader

The manual fertilizer cart (CIMMYT) with dual fluted roller metering devices optimally applies inorganic fertilizers using a bicycle-wheel-driven system for precise, low-effort application in a single pass between crop rows.

©CIMMYT/Jelle Van Loon

Hermetic silo

The galvanized steel silo on-farm storage technology (CIMMYT) provides medium and long-term grain and seed conservation. The silo's hermetic design protects grains and seeds, eliminating the need for additional pesticides.

©CIMMYT/Jelle Van Loon

Crop Tiger combine harvester

A multicrop harvester (CLAAS) with a 76 hp Tata BSIII engine, suitable for wheat, rice, soybean, mustard, pulses and maize, featuring a Tangential Axial Flow (TAF) threshing system, universal joint grain unloading, and a covered grain tank, designed for medium to large fields.

©FAO/Godfrey Omulo

DOMINATOR combine harvester

A user-friendly MULTICROP 5-walker machine offering improved straw quality, larger sieve and separation area, CLAAS technology, expanded threshing drum, increased grain tank capacity and faster unloading.

©FAO/Godfrey Omulo

New Holland CX7 combine harvester

The New Holland CX7 and CX8 range, introduced in 2001, has redefined combine harvesting productivity. The optional Ultra-Flow™ staggered drum improves threshing performance, offering smoother crop flow, quieter operation, lower fuel consumption and up to a 10 percent capacity increase.

©FAO/Godfrey Omulo

Farmall A four-wheel tractor

The Farmall 90-100 A series (CNH Industrial) is a robust and versatile tractor designed to meet the needs of part-time and full-time farmers. Its strong engine and great maneuverability make it suitable for a wide range of tasks, whether as a primary or additional tractor.

©FAO/Cristiano Minichiello

T6 Methane Power four-wheel tractor

The New Holland T6 Methane Power is the world's first 100 percent methane-powered production tractor, playing a crucial role in the energy-independent farm system. It operates on biomethane generated from crop waste and assists in crop cultivation, completing a sustainable cycle.

©FAO/Godfrey Omulo

Matabi Evolution 15 LTC

This battery-powered sprayer (GOIZPER GROUP / MICRON) allows precise application of insecticides, fungicides, and herbicides, thanks to two working position selectors (herbicide and insecticide/fungicide).

©FAO/Cristiano Minichiello

48 hp four-wheel tractor

The TYM compact tractor is ideal for narrow spaces, saving time and labour for various gardening tasks. It is versatile for orchards, vegetable and fruit beds, and smaller greenhouse operations.

©FAO/Godfrey Omulo

276 hp four-wheel tractor

The 6R family excels in transport and automation with advanced features such as 1-Click-Go-AutoSetup for site-specific farming. These robust, low-weight tractors offer excellent pulling power and integrate user-friendly John Deere precision agriculture technology for planning, monitoring, executing and analysing farming operations, enhancing efficiency, sustainability and profitability.

©FAO/Godfrey Omulo

23.4 kWh electric compact tractor

Kubota's new LXe-261 is a four-wheel drive, 26 hp electric tractor with a fast one-hour CHAdeMO battery charging system. It offers continuous operation with a four-hour charge and quick recharge during lunch breaks, making it ideal for green-space management tasks such as mowing and hauling. No need to pause work for long charging times or switching to another vehicle.

©FAO/Godfrey Omulo

Fodder Chopper, Paddy Reaper, Axial Flow Pump, Jute fibre extractor machine, Pond surge aerator, Impeller aerator and PV support

The International Development Enterprises (IDE) collection of machinery is a private-sector initiative that provides farmer-friendly technologies, benefiting 1.5 million Bangladeshi households by 2004. IDE's "firm to farm" approach links national firms with over 30,000 last-mile entrepreneurs, enabling sustainable access to seed, fertilizer, and advisory services, thereby enhancing incomes and opportunities for farmers.

©FAO/Cristiano Minichiello

Specialized standard tractor

The Kubota M5002N is a compact tractor designed for narrow spaces like orchards and vineyards. It has a 3.8-litre diesel engine that meets EU Stage V emission standards, reducing ownership costs with an efficient diesel particulate filter. The M5N also has advanced emissions control, enabling diesel particulate filter regeneration at low RPM (1,100) and extending its service life to 6,000 hours, as well as 500-hour engine oil change intervals.

©FAO/Francisco Martinez

Kubota XTA sprayer with H3O technology

The Kubota XTA sprayer with H3O technology is a smart, precision sprayer for specialty crops. It reduces spray drift by up to 50% and pesticide use by 25%, while maintaining pest and disease control. The H3O system also saves 4 liters of fuel per hour and provides real-time work traceability, promoting environmentally-friendly farming and improving food security.

©FAO/Francisco Martinez

Multipurpose robot

The Oz robot from Naïo Technologies is a versatile, 100% electric, user-friendly machine weighing 160 kg that can tow trailers. Its batteries provide up to 8 hours of power and can be recharged 80% in 6 hours. Since its launch in 2013, over 250 Oz units have been sold globally, assisting growers with tasks like weeding, furrowing, sowing, and load carrying across a wide range of crops using its RTK GPS-based guidance system

©FAO/Giuseppe Carotenuto

Specialized plough

The Delfino3s from Nardi SLR is a unique plough for large-scale land rehabilitation that mechanizes traditional rainwater harvesting techniques. It features a reversible mouldboard that creates 3.5-5 m long, 40-50 cm wide, and 40-50 cm deep micro basins using a wave motion. A ripper positioned in front of the plough cracks the soil 60-70 cm deep, forming an underground furrow to collect water from the adjacent micro basins. This system helps gather rainwater, topsoil, seeds, and organic materials, aiding long-term land regeneration. The Delfino3s is used to combat soil erosion and desertification using the Vallerani System approach.

©FAO/Godfrey Omulo

Cereal crusher / mill with rollers

The CRUSH 3 from Peruzzo SLR is a crushing machine with two robust rollers designed to process various cereals. Crushing the cereals enables efficient animal feeding, quick digestion without altering their properties, and rapid absorption by the digestive system. The finely crushed grains can be separated through screening, allowing the extraction of finer flour suitable for "00" flour production for human food applications.

©FAO/Francisco Martinez

Solix AG robot

The Solinftec robotic platform collects field data for precision agriculture, featuring scouting, spraying, and pest control capabilities. The scouting function continuously monitors plant health, nutrition, and pests. The sprayer targets early-stage weeds with minimal inputs. The hunter lures and eliminates pests using light and electroshocks.

©FAO/Giuseppe Carotenuto

Digital Farmhand robot

The Digital Farmhand, developed by the University of Sydney, is an affordable electric platform that provides AI-powered tools for smallholder farmers. It utilizes smartphone technology, machine learning, and robotics to offer real-time crop information, pest detection, yield assessment, and task automation.

©FAO/Godfrey Omulo

No-tillage planter

The Vella Semina Diretta pneumatic planter is designed for no-till soil, saving labor and time while supporting conservation agriculture. It uses pneumatic seed distribution for precise and efficient planting. The planter can integrate digital field maps to adjust seed and fertilizer rates, and creates seed ridges that are sealed after planting.

©FAO/Godfrey Omulo

Agricultural drone

The XAG P100 agricultural drone is a fully autonomous UAV for seeding, spraying and fertilizing with the following specifications:

- 45 kg load capacity
- 40 L spray tank or 60 L granule container
- Quick change between spraying and spreading configurations
- Centrally automized droplet size: 60 μm–400 μm
- Flow rate (single pump): 0.3 L–6 L/min
- IP67 protection

©FAO/Godfrey Omulo

Agricultural drone

The autonomous R150 robot aids farmers with tasks such as crop spraying, mowing and goods transport. It offers fully autonomous functions such as precision spraying, load transportation, "follow me" mode and mowing. The XAG R150 2022 aims to increase field work efficiency. Specifications include:

- 200 kg load capacity
- 150-litre spray tank
- Maximum cutting width of 90 cm

©FAO/Giuseppe Carotenuto

Two-wheel tractor seeder

The SM Seeder by Bassi Seminatrici srl is a versatile professional machine suitable for a variety of crops including vegetables, legumes, and maize. It is modular, durable, and highly customizable, enabling efficient and precise sowing tailored to different agricultural needs.

Ridger

The Ridge 2 dynamic ridger by BCS S.p.A is a specialized front attachment for ridging. It clears inter-row earth and places it around the base of plants, or can be used to weed furrows. The working depth and width are adjustable, providing versatile use.

Biomass chipper

The TB50 by Peruzzo SLR is a drum-type shredder designed for cutting branches up to 6-7 cm in diameter, ideal for private users, renters, and small-scale green maintenance. It excels at shredding pruning debris while maintaining high productivity, thanks to its two reversible durable blades and an additional tempered steel control blade.
The output is expelled at a height of 142 cm and a distance of 2-3 m, convenient for loading into containers.

Electric-powered hammer mill

The hammer mill (Peruzzo SLR) is used to grind various types of cereals with a moisture content of up to 15 percent.
It allows for the production of different flour sizes by changing the sieves with varying hole diameters, ranging from coarse for animal feed to fine for human consumption.

Annex 2

Side event "Voices from young people on sustainable agricultural mechanization"

Introduction

The side event "Voices from young people on sustainable agricultural mechanization" was tailored for young people in the agrifood sector. It gave young agricultural professionals from across the globe an opportunity to raise their voices on key issues from their own experiences in the context of sustainable mechanization in the agrifood sector.

Programme

- Opening remarks

Beth Bechdol, Deputy Director-General, FAO, Rome, Italy

- A young entrepreneur's journey: opportunities in agricultural hire business models

Samuel Kouamé, CEO and founder, Ferm'Bio SARL, Côte d'Ivoire

- Hire services of scale-appropriate sustainable mechanization

Yashim Reyes, Technical advisor, CIMMYT, Mexico

- From policy to action in support of youth-lead agricultural mechanization initiatives

Sanjeeb Bimali, Agricultural Engineer, Center of Agricultural Infrastructure and Agricultural Mechanization Promotion, Department of Agriculture, Harihar Bhawan, Lalitpur, Nepal

- Innovation hubs for scaling youth entrepreneurship in the digital-agrifood sector

Aziza Cheikhna, Co-founder and catalyst, Hadina RIMTIC Incubator, Nouakchott, Mauritania

- Agrobotics for sustainable mechanization: the story of E-Terry

Martha Wenzel, CEO and co-founder, E-TERRY GmbH, Erfurt, Germany

- Closing remarks

Josef Kienzle, Agricultural Engineer, FAO, Rome

Moderators

Mayling Flores Rojas, Agricultural Engineer, NSP, FAO

Vuyo Maphango, Agricultural Engineer, NSP, FAO

SUMMARY OF PRESENTATIONS

Opening remarks

Beth Bechdol

Deputy Director-General, FAO

Operating a farm today requires operating equipment and making important purchasing and evaluation decisions about technology, seed varieties, marketing, how and when to plant and harvest, and how to conserve crops. That is a lot of decision-making for a young person. Today, young people will share their personal experiences on how they have been active, how they have built businesses, how they have engaged with farmers, and how they have positioned themselves inside the agrifood system.

Agriculture is moving from 1.0 to 3.0; and now we talk about agriculture 5.0 that has moved beyond even digitalization. The next generation has fresh perspectives, enthusiasm and inherent understanding of modern and digital technologies. Their technology skills, proficiency and adaptability are incredible assets as we reimagine food and agriculture. Transforming agrifood systems requires bold ideas and creativity. The FAO Strategic Framework 2022–2031 outlines how FAO works with its Members and partners to transform agrifood systems to become more efficient, inclusive and resilient for better production, nutrition, environment and life, leaving no one behind. Organizations such as FAO should more frequently provide platforms for young people to share their stories and narratives. It is getting harder to convince a generation growing farther away from farms about the inspiring opportunities of being part of food and agriculture. Therefore, we must change the way we communicate on food and agriculture.

A young entrepreneur's journey: opportunities in agricultural hire business models

Samuel Kouamé

CEO and founder, Ferm'Bio SARL, Côte d'Ivoire

Ferm'Bio SARL is a Côte d'Ivoire–based company that aims to contribute to the national and international advancement of Ivorian agriculture. The company offers diversified mechanized agriculture services, including ploughing, pulverization, ridging, cereal seeding, mechanized land maintenance, cereal threshing and winnowing (maize, rice, soybean, beans), phytosanitary treatments and transport of agricultural products to processing areas. Ferm'Bio SARL also produces high-yield, short-cycle, disease-resistant quality seeds for food crops, and conducts marketing for agricultural products from farmers grouped into platforms at a remunerative price before crop planting. The company's clients are farmers grouped in cooperatives that are members of the Manioc Platform for the Bélier Region, which comprises 206 cooperatives and 1 850 producers. Ferm'Bio SARL is a member of the Platform and actively participated in its establishment in 2019. In 2022, the company covered 1 255 ha.

Hire services of scale-appropriate sustainable mechanization

Yashim Reyes

Agricultural Mechanical Engineer, CIMMYT, Mexico

Following a study of production systems for basic grains in Oaxaca, a machine-hire centre was established to create local capacity for scale-appropriate mechanization. The centre aims to evaluate different seeders, learn about innovative equipment that can help farmers, identify areas for improvement in these machines and develop some models of machines, including post-harvest options, with trained personnel from the area. Observations and recommendations for the efficient use of some models of animal draft planters are presented. Farmers from different agroecological contexts and social environments participate to offer options that meet the requirements of different production systems. Emphasis is placed on the participation of women, young people and children to promote the sustainable mechanization of agrifood systems in Oaxaca.

From policy to action in support of youth-lead agricultural mechanization initiatives

Sanjeeb Bimali

Agricultural Engineer, Centre of Agricultural Infrastructure and Agricultural Mechanization Promotion, Department of Agriculture, Harihar Bhawan, Lalitpur, Nepal

The Nepalese government engages in machinery promotion, capacity building and institutional development to promote agricultural mechanization.

The Agricultural Development Strategy (2015) and the Agricultural Mechanization Promotion Policy (2014) align with the new constitution of the Federal Republic of Nepal and focus on creating an enabling environment for local manufacturers and established custom hiring centres. Machinery promotion activities include agricultural mechanization exhibitions, technology demonstrations and subsidy schemes. Capacity-building activities include the development of training for trainers on operation and machinery use, repair and maintenance, and business-development training. The government has focused on developing custom-hiring centres to provide services through a public–private partnership model. There are mainly four different types of custom-hiring centres based on the managing agency: privately managed, cooperative managed, farmer-group managed and mechanization-service-group managed. Privately managed custom-hiring centres have been providing better service with uniform service rates to all users.

Innovation hubs for scaling youth entrepreneurship in the digital-agrifood sector

Aziza Cheikhna

Co-founder and catalyst, Hadina RIMTIC Incubator, Nouakchott, Mauritania

Hadina RIMTIC is a leading business incubator and technology hub in Mauritania, with nearly 10 years of experience in start-up incubation, acceleration, entrepreneurship development, innovation and education in science, technology, engineering and mathematics. It prepares entrepreneurs and innovators to navigate the different stages of building high-growth, innovation-driven companies from idea to product-market fit. Hadina also provides tailored programmes and technical training to reduce unemployment risk for young graduates and improve the skills and technical expertise of the young Mauritanian workforce. Hadina has supported the launch of companies in health, e-commerce, education, financial technology, arts, agribusiness, software development, green building, waste management and green technology. Some of its flagship start-ups include RIM COMPST, ANDI-AGRO.sarl (Njuman), Habidem, Cadorim, Dadoo VDP and MinouStore (now Express.Mr).

Agricultural robotics for sustainable mechanization: the story of E-TERRY

Martha Wenzel

CEO and co-founder, E-TERRY GmbH, Erfurt, Germany

E-TERRY is a German robotics start-up that builds an autonomous agricultural robot to advance sustainable agriculture on a large scale. The robot tackles issues in organic farming practices, such as high manual labour needs combined with severe staff shortages, through automation and artificial intelligence. The patented E-TERRY robot is highly flexible and adapts dynamically to different crops and growth stages. It can be deployed in many different fields with a high variety of crops on small areas. The robot mechanically removes weeds in vegetable crops and will integrate more applications such as precision spraying or monitoring specific parameters such as crop health and water availability. E-TERRY combines robust hardware with AI and enables farmers to care for their fields in the optimal economic and ecological manner, benefiting both growers and the environment.

Closing remarks

Josef Kienzle

Agricultural Engineer, NSP, FAO

This side event has been inspiring and remarkable, with diverse voices and different stories and experiences from around the world contributing to an important discussion around innovation and progress in the field of sustainable agricultural mechanization. It is encouraging to see the involvement and enthusiasm of young people, who are making a real impact in the field. We all need to continue discussions on this important topic, as we rely on the future generation of farmers, engineers and entrepreneurs to continue making a difference.

Annex 3
Side event "Using precision seeding to optimize crop yields"

Introduction

The main objective of this side event was to bring together notable experts and users of precision seeding technologies to present information on the performance and benefits of modern planting technologies in varying farming circumstances and to share ideas with a diverse audience with the view to educate, raise awareness, discuss potential areas of opportunity and clarify misconceptions that may serve as barriers to technology adoption.

Programme

- Welcome address and opening remarks
- Chikelu Mba, Deputy Director, NSP, FAO
- Evolution and trends in precision seeding
- Maik Freitag, Sales and Product Manager, Novag
- Precision seeding technologies for sustainable crop production
- Gabriela Cruz, European Conservation Agriculture Federation (ECAF); President, Board of Directors of the Portuguese Association for Conservation Tillage (APOSOLO)
- No-till precision seeding and the management of crop residues as soil cover
- Marie Bartz, Researcher, Centre for Organic and Regenerative Agriculture (CARe-Bio)
- The potential of advanced precision seeding techniques using cutting-edge technologies to increase crop productivity
- Hongwen Li, Professor, China Agricultural University, Beijing, China
- The potential benefits of precision seeding technologies and how to increase adoption by smallholder farmers.
- Saidi Mkomwa, Executive Director, African Conservation Tillage Network, Kenya

Moderators

Theodor Friedrich, independent expert, Germany

SUMMARY OF PRESENTATIONS

Opening remarks

Chikelu Mba

Deputy Director, NSP, FAO

In 2021, almost 30 percent of the global population were moderately or severely food insecure, and almost 12 percent faced severe food insecurity. Erratic extreme weather events, attributed to climate change, are increasing in frequency and intensity, exacerbating the situation. The COVID-19 pandemic has upended food systems and supply chains. Conflicts around the world have coalesced into a perfect storm that imperils global agrifood systems. The FAO Strategic Framework 2022–2031 outlines how FAO works with its Members and partners to transform agrifood systems to become more efficient, inclusive and resilient for better production, nutrition, environment and life, leaving no one behind. At FAO, we aim to enable this transition through optimization and minimization, by optimizing the positive aspects of production systems such as yield, productivity, nutritional quality and resilience, while minimizing the negative aspects of the systems such as environmental footprints and yield losses. Quality seeds are foundational to achieving better production, nutrition, environment and life. That is why we work to improve farmers' timely access to enough quality seeds of the most suitable crop varieties. Precision seeding enables us to achieve this by maximizing efficiency. Today, young people will share their personal experiences on how they have been active, how they have built

Evolution and trends in precision seeding

Maik Freitag

Sales and Product Manager, Novag GmbH, Hannover, Germany

Precision seeding technologies are used for both tilled and no-till conditions. There is increasing interest in developing specialized seeding equipment for planting seeds in no-tilled soils with the same precision as in mechanically prepared soils and effectively managing crop residue. It is possible to reduce costs and perform efficient seeding by upgrading existing, rather expensive, seeders with new precision seeding technology. It is hoped that with the rapid and widespread adoption of no-tillage agriculture all over the world, continued research and development would generate cheaper and more affordable no-tillage seeders in the future.

Precision seeding technologies for sustainable crop production

Gabriela Cruz

Farmer, European Conservation Agriculture Federation (ECAF); President, Board of Directors of the Portuguese Association for Conservation Tillage (APOSOLO)

My farm in Portugal covers 700 ha and aims to produce safe food, feed, fibres, biofuels and ecosystem services while protecting natural resources and the environment. The farm has adopted a no-till approach since 1998, but only acquired suitable machinery in 2009. The farm has reduced the use of agrochemicals, fuel and water while minimizing soil erosion and carbon dioxide emissions. Precision seeding is successful when it results in good soil moisture and temperature, accurate seed metering and placement at precise spacing and depth in the furrow during planting, timely and uniform seed emergence, maximizing yield potential, specific planter components and the right planting speed. The pneumatic precision seed drill is preferable to the mechanical precision seed drill for this purpose.

No-till precision seeding and the management of crop residues as soil cover

Marie Bartz

Researcher, Centre for Organic and Regenerative Agriculture (CARe-Bio)

Crop residues on the soil surface can pose a challenge for seeding in no-till conditions. Specialized seeding equipment has been developed to place seeds in undisturbed soils with the same precision as in mechanically prepared seed beds. These precision seeders perform efficient seeding operations and also manage crop residues effectively. The usefulness of seeding technologies depends on the management of residues of the preceding crops or cover crops. In this way, management of the soil cover becomes an integral part of the seeding technology. Specialized tools are developed for this process to replace conventional seed bed preparation tools. Retrofitting existing equipment with new technology is often more efficient and cost-effective than investing in sophisticated new machines using expensive technology.

The potential of advanced precision seeding techniques using cutting-edge technologies to increase crop productivity

Hongwen Li

Leader/Professor, Conservation Tillage Research Center (CTRC), China Agricultural University

Precision seeding has become more efficient with the use of cutting-edge technologies that are applied in seed bed preparation, precision seed metering and delivery, and seeding depth control. The starting point of precision sowing is a clean seed bed. The clean seed bed together with consistent row spacing and seeding depth are beneficial for improving the accuracy of seeding.
To prepare a clean bed for seeding, a power-driven disc equipped with autonomous guidance technology and machine vision with satellite navigation is used to cut through straw and stubble. The seeds are subsequently sown in uniform row spacing and in a precise and even manner using mechanical and pneumatic precision metering and delivery devices with photoelectric sensors for monitoring the seed and electric drive systems that ensure accurate regulation of operating speeds.
Automatic control technologies for soil profiling and pressure compaction are also used to ensure consistent and stable seeding depth.

The potential benefits of precision seeding technology and how to increase adoption by smallholder farmers

Saidi Mkomwa

Executive Director, African Conservation Tillage Network, Kenya

Despite the potential benefits of precision seeding, the majority of smallholders globally do not have access to this technology. Precision seeding can give optimal and sustainable benefits to smallholders in mechanized conservation agriculture systems. Low-cost, simple machines aimed at smallholders include manually operated precision hand jabs and animal-traction planters, which can place seeds and fertilizers with precision into untilled soils with vegetative mulch cover. This can lead to increased efficiency in input use, optimal yields and the saving of labour. With efficient and reduced use of agrochemicals, water, fuel and machinery, direct precision seeding offers a pathway to greener production systems and farming in the future.

Annex 4
Conference organizational bodies

Organization

The Global Conference on Sustainable Agricultural Mechanization (GAMC) was organized by FAO with the support of an Organizing Committee (OC) and a Secretariat.

Organizing Committee

The specific role of the Organizing Committee is to: (1) develop a programme covering the main conference topics, with proposals for the names of potential keynote speakers, presenters, panellists, chairs and rapporteurs; (2) in developing the programme, follow guidance from the Secretariat to ensure balance with respect to gender, geographic areas and stakeholder groups of speakers/chairs/panellists; (3) in developing the programme, request inputs from professional colleagues and agree on the final programme through consensus from the OC; (4) provide advice to the Secretariat, when requested; (5) provide advice on resource mobilization, when requested; (6) act as the event's ambassador among organizations/networks/countries of members; (7) encourage people to attend the conference; and (8) provide advice on potential follow-up actions to the conference.

COMPOSITION

Chairperson:

- **Beth Bechdol**, Deputy Director-General, Food and Agriculture Organization of the United Nations (FAO)

Co-chairperson:

- **Josse De Baerdemaeker**, Professor, KU Leuven

Vice-chairpersons:

- **H.E. Josefa Leonel Correia Sacko**, Commissioner for Agriculture, Rural Development, Blue Economy, and Sustainable Environment, African Union Commission (AUC)
- **Bram Govaerts**, Director-General, International Maize and Wheat Improvement Center (CIMMYT)
- **Alessandro Malavolti**, Vice-President, European Agriculture Machinery Industries Association (CEMA)
- **Chunjiang Zhao**, Professor, National Engineering Research Center for Information Technology in Agriculture (NERCITA), Beijing, China
- **Louisa Parker-Smith**, Director, Global Sustainability, AGCO Corporation

Technical sessions chairpersons and co-chairpersons:

- **Rabe Yahaya**, Senior Scientist, Mechanization and Postharvest Management, International Rice Research Institute (IRRI), Uttar Pradesh, India
- **Regina Birner**, Chair, Social and Institutional Change in Agricultural Development, University of Hohenheim
- **Chakib Jenane**, Practice Manager, Agriculture and Food Global Practice, Western and Central Africa, World Bank
- **Dinh Thi Tran**, Head of Department, Food Processing Technology, Viet Nam National University of Agriculture (VNUA)
- **Akylbek Kurishbayev**, Chair of the Board–Rector, Kazakh National Agrarian Research University; Vice-President, National Academy of Science under the President of the Republic of Kazakhstan
- **Mohammad Esmaeil Asadi**, Senior Research Scientist, Golestan Agricultural and Natural Resources Research and Education Center, Gorgan, Islamic Republic of Iran
- **Salah Sukkarieh**, Professor, Robotics and Intelligent Systems, Sydney University
- **Cornelia Weltzien**, Professor, Department of Agromechatronics, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany
- **Ignacio Ruiz**, ANSEMAT, General Secretary; Agrievolution Alliance, President
- **Anshuman Varma**, Deputy-Head, United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Centre for Sustainable Agricultural Mechanization (CSAM)
- **Saidi Mkomwa**, Executive Secretary and Chief Executive Officer, African Conservation Tillage Network
- **Hiroyuki Takeshima**, Senior Research Fellow, Development Strategy and Governance Division, International Food Policy Research Institute (IFPRI)
- **Geoffrey C. Mrema**, Professor, Sokoine University, United Republic of Tanzania; Former Director, FAO (retired)
- **Tom Goddard**, former Senior Government Advisor, Sustainable Land Development, Alberta, Canada

External members:

- **Arianna Giuliodori**, Secretary General, World Farmer's Organisation (WFO)
- **Gerald Masila**, Executive Director, Eastern Africa Grain Council
- **Bing Zhao**, Director, Agricultural Partnerships and Multilateral Engagement, Strategic Partnerships Division, World Food Programme (WFP)
- **Robert Delve**, Lead Global Technical Advisor, Agronomy, Sustainable Production, Markets and Institutions Division, Strategy and Knowledge Department, International Fund for Agricultural Development (IFAD)
- **Varma Anshuman**, Deputy-Head, ESCAP-CSAM
- **Chakib Jenane**, Practice Manager, Agriculture and Food Practice for West and Central Africa, World Bank, Washington, United States of America

Internal members:

- **Selvareju Ramasamy**, Senior Agricultural Officer, Office of Innovation (OIN), FAO
- **Mohamed Manssouri**, Director, FAO Investment Centre (CFI), FAO
- **Giulia Santarelli**, Programme Support Specialist, FAO Investment Centre (CFI), FAO
- **Guilherme Brady**, Head of Family Farming Engagement and Parliamentarian Networks Unit (PSUF), FAO
- **Ivan Prusina**, Senior Programme Officer, Resource Mobilization and Private Sector Partnerships (PSR), FAO
- **Lauren Phillips**, Deputy Director, Inclusive Rural Transformation and Gender Equality (ESP), FAO
- **Anping Ye**, Director, South–South and Triangular Cooperation (PST), FAO
- **Divine Njie**, Deputy-Director, Food Systems and Food Safety (ESF), FAO
- **Lynnette Neufeld**, Director, Food and Nutrition (ESN), FAO
- **Marco Sánchez Cantillo**, Deputy-Director, Agrifood Economics (ESA), FAO

- **Thanawat Tiensin**, Director, Animal Production and Health (NSA), FAO
- **Lifeng Li**, Director, Land and Water (NSL), FAO
- **Wu Zhimin**, Director, Forestry (NFO), FAO
- **Xinhua Yuan**, Deputy-Director, Fisheries and Aquaculture (NFI), FAO

Focal Points from FAO Regional Offices:

- **Nomathemba Mhlanga**, Regional Office for Africa (RAF)
- **Bo Zhou**, Regional Office for Asia and the Pacific (RAP)
- **Daniela Di Gianantonio**, Regional Office for Europe and Central Asia (REU)
- **Soroush Parsa**, Regional Office for Latin America and the Caribbean (RLC)
- **Ahmad Mukhtar**, Regional Office for the Near East and North Africa (RNE)

Executive Secretary:

- **Jingyuan Xia**, former Director, FAO Plant Production and Protection Division.

Secretariat

The Secretariat was in charge of the organization of the conference, including its programme, logistics and communication.

COMPOSITION

Executive Secretary:

- **Jingyuan Xia**, former Director, Plant Production and Protection Division (NSP), Food and Agriculture Organization of the United Nations (FAO)

Coordinator:

- **Josef Kienzle**, Agricultural Engineer, NSP, FAO

Assistant coordinators:

- **Karim Houmy**, Agricultural Engineer, NSP, FAO
- **Hafiz Muminjanov**, Technical Adviser, NSP, FAO
- **Haekoo Kim**, Technical Adviser, NSP, FAO

Focal points of thematic sessions:

- **Mayling Flores Rojas**, Agricultural Engineer, NSP, FAO
- **Buyung Hadi**, Agricultural Officer, NSP, FAO
- **Wilson Hugo**, Agricultural Officer, NSP, FAO
- **Ronnie Brathwaite**, Senior Agricultural Officer, NSP, FAO
- **Joseph Mpagalile**, Investment Support Officer, CFIA, FAO
- **Santiago Santos-Valle**, Agricultural Engineering Consultant, NSP, FAO
- **Shangchuan Jiang**, Project Manager, NSP, FAO
- **Ivan Landers**, Agricultural Officer, NSP, FAO

Core members for operations and support:

- **Fenton Beed**, Senior Agricultural Officer, NSP, FAO
- **Alessia Laurenza**, Office Assistant, NSP, FAO
- **Elena Guilavogui**, Office Assistant, NSP, FAO
- **Bruno Telemans**, Sustainable Crop Production

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- **Paul Howard**, Office Assistant, NSP, FAO
- **Shangchuan Jiang**, Project Manager, NSP, FAO
- **Nadine Aschauer**, Sustainable Plant Production

Consultant, NSP, FAO

- **Vuyo Maphango**, Sustainable Agricultural

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- **Godfrey Omulo**, Agricultural Engineer, NSP, FAO
- **Tania White**, Programme Associate, NSP, FAO
- **Elena Rotondo**, Office Assistant, NSP, FAO
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Working groups:

- **Programme:** Josef Kienzle, Hafiz Muminjanov, Karim Houmy, Mayling Flores Rojas, Buyung Hadi, Wilson Hugo, Joseph Mpagalile, Santiago Santos Valle, Haekoo Kim, Ivan Landers
- **Communication:** Haekoo Kim, Linda Perella, Isabella Trapani, Denise Martinez-Breto, Francisco Martinez, Diana Gutierrez Mendez, Ginevra Virgili, Micah Goldsmith, Lucia Albanese
- **Operations/Logistics:** Alessia Laurenza, Bruno Telemans, Paul Howard, Shangchuan Jiang, Nadine Aschauer, Vuyo Maphango, Godfrey Omulo, Tania White, Elena Rotonda, Elena Guilavogui, Laura Ciccariello, Diana Gamal
- **Exhibition:** Fenton Beed, Josef Kienzle, Santiago Santos-Valle, Karim Houmy, Alessia Laurenza, Bruno Telemans, Diana Gutierrez Mendez, Linda Perella, Simona Capocaccia, Cristiana Giovannini

Observers:

- **Ariella Glinni**, Senior Technical Officer, NSP, FAO
- **Dina Rahman**, Senior Coordinator, ODG, FAO
- **Diana Gutierrez-Mendez**, Communications Officer, DDGB, FAO

Annex 5

Conference programme

The programme includes the inauguration of the joint agricultural machinery and livestock exhibition, and two side events.

Tuesday, 26 September 2023

18.15–19.00

INAUGURATION OF THE JOINT AGRICULTURAL MACHINERY AND LIVESTOCK EXHIBITION (Atrium | Outside building A)

Masters of ceremony

Beth Bechdol and **Maria Helena Semedo**, Deputy Directors-General, FAO

Inauguration remarks

QU Dongyu, Director-General, FAO
Alessandro Malavolti, Vice-President, European Agricultural Machinery Industry Association (CEMA)
Altantuya Tseden-Ish, Chair, Asian Farmers' Association for Sustainable Rural Development (AFA) and President, National Association of Mongolian Agricultural Cooperatives

19.00

Exhibition cocktail (FAO Atrium, ground floor)

Wednesday, 27 September 2023

09.30–9.50

CONFERENCE OPENING

Moderator: **Beth Bechdol**, Deputy Director-General, FAO

Opening remarks

QU Dongyu, Director-General, FAO

Opening statement

Patrizio Giacomo La Pietra, Undersecretary of State, Italian Ministry of Agriculture, Food Sovereignty and Forestry

10.00–12.30

PLENARY SESSION 1

Keynote address section A

Moderator: **Maria Helena Semedo**, Deputy Director-General, FAO

- A.1 Mechanization for sustainable agrifood systems
  H.E. Josefa Sacko, Commissioner for Agriculture, Rural Development, Blue Economy, and Sustainable Environment, the African Union Commission (AUC)
- A.2 Farmer-led Sustainability, Resiliency and Climate-Smart Agriculture
  Robert Bonnie, Under Secretary for Natural Resources and Environment, United States Department of Agriculture (USDA)
- A.3 Climate change and mechanization
  Bram Govaerts, Director-General, International Maize and Wheat Improvement Center (CIMMYT)
- A.4 Farm power and energy source innovations
  Alessandro Malavolti, Vice-President, European Agriculture Machinery Industries Association (CEMA)
- Discussion

Keynote address section B

Moderator: **Vincent Martin**, Director, Office of Innovation, FAO

- B.1 Digitalization for agrifood systems transformation
  Chunjiang Zhao, Professor, National Engineering Research Center for Information Technology in Agriculture (NERCITA), Beijing
- B.2 Automation trends in agriculture
  Louisa Parker-Smith, Director, Global Sustainability, AGCO Corporation
- B.3 Policies and regulations for sustainable agricultural mechanization and digitalization
  Josse De Baerdemaeker, Professor, KU Leuven
- Discussion

12.30–14.00

Lunch break

Joint agricultural machinery and livestock exhibition

THEMATIC SESSIONS 1.1 AND 2.1

Thematic session 1
Mechanization for crop production

14.00–15.30

Session 1.1: Efficiency and productivity

Chair:

- Rabe Yahaya, Senior Scientist, Mechanization and Postharvest Management, International Rice Research Institute (IRRI), Uttar Pradesh, India

Key panellist:

- Andreas Hastedt, CEO, Machines Ring Harburg

Rapporteurs:

- Wilson Hugo, Agricultural Officer, FAO
- Ivan Landers, Agricultural Officer, FAO

- Opening remarks (5 minutes)
- Sustainable agricultural mechanization and crop production – exploration and practice of unstaffed farm (10 minutes)
  Xiwen Luo, Professor, Academician, South China Agricultural University, China
- Smallholder agricultural mechanization in developing countries – bridging the agricultural gap (10 minutes)
  Stanley Silwimba, Senior Manager – Programmes and Commercialization, Conservation Farming Unit, Zambia
- Empowering women and marginalized groups through agricultural mechanization (10 minutes)
  Eva Marina Valencia Leñero, Scaling Coordinator, CIMMYT, CGIAR
- Mechanization at the service of new environmentally friendly practices (10 minutes)
  Peter Groot Koerkamp, Professor in Biosystems Engineering / Agrotechnology and managing chair holder at the Farm Technology Group of Wageningen University
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 2
Post-harvest and agroprocessing

Session 2.1: Harvest and post-harvest

Chair:

- Chakib Jenane, Practice Manager, Agriculture and Food Global Practice, Western and Central Africa, World Bank

Key panellist:

- Dieudonne Baributsa, Professor of Entomology, Purdue University

Rapporteurs:

- Mayling Flores-Rojas, Agricultural Engineer, FAO
- Joseph Mpagalile, Agricultural Engineer, FAO

- Opening remarks (5 minutes)
- Integrated approach for a better harvest and postharvest management and technologies (10 minutes)
  Romina Pedreschi, Associate Professor, School of Agronomy, Pontificia Universidad Católica de Valparaíso, Chile
- Innovations and advanced technologies to reduce post-harvest losses and increase income (10 minutes)
  Bart Nicolai, Full professor, Department of Biosystem, KU Leuven, Belgium
- Drying and storage technologies for grains (10 minutes)
  Guangqiao Cao, Deputy Director, Nanjing Research Institute for Agricultural Mechanization, China
- Importance of washing, hygine, drying, precooling and correct packaging for better operational and supply chain management (10 minutes)
  John Christopher Duffill, CEO, John Crop Development International and John Crop Development, Viet Nam
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

15.30–16.00

Break

THEMATIC SESSIONS 1.2 AND 2.2

Thematic session 1
Mechanization for crop production

16.00–17.30

Session 1.2: Innovative technologies

Chair:

- Regina Birner, Chair, Social and Institutional Change in Agricultural Development, University of Hohenheim

Key panellist:

- Gajendra Singh, Director, Chair, Science Committee, Appropriate Scale Mechanization Consortium of the University of Illinois, Michigan State University, Kansas State University and North Carolina Agricultural and Technical State University

Rapporteurs:

- Wilson Hugo, Agricultural Officer, FAO
- Ivan Landers, Agricultural Officer, FAO

- Opening remarks (5 minutes)
- Alternative power/fuel sources combined with automated solutions (10 minutes)
  Giulia Catini, Head of EU Affairs, CNH Industrial
- Innovations in precision planting: the role of seed pelleting (10 minutes)
  Christine Hazel, Global Regulatory Lead for Seed Applied Technologies, Corteva, United States of America
- Innovations in crop protection: precision application technologies for agrochemicals and options for mechanical weed control (10 minutes)
  Virender Kumar, Senior Weed Scientist, International Rice Research Institute (IRRI)
- Innovations in protected cultivation: automation and robotics for crop production (10 minutes)
  Naoshi Kondo, Professor, Sensing technologies and automation for biological and agricultural products, Kyoto University, Japan
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 2
Post-harvest and agroprocessing

Session 2.2: Agroprocessing

Chair:

- Dinh Thi Tran, Head of Department, Food Processing Technology, Viet Nam National University of Agriculture (VNUA)

Key panellist:

- Esther Obadiah, Secretary, Women Mechanized Agro Service Provider Cooperative

Rapporteurs:

- Mayling Flores-Rojas, Agricultural Engineer, FAO
- Joseph Mpagalile, Agricultural Engineer, FAO

- Opening remarks (5 minutes)
- Agroprocessing global perspective – drivers and triggers for transformation (10 minutes)
  Umezuruike Linus Opara, Chair, DSI-NRF SARChI Postharvest Technology, Director, Africa Institute for Postharvest Technology
- Protein transition food (examples from Kenya and Mexico) (10 minutes)
  Dorte Verner, Lead Agriculture Economist, World Bank
- Agroprocessing business on cocoa processing to export (standards, traceability, financing, sourcing, quality control) (10 minutes)
  Patricia Poku-Diaby, Businesswoman, cocoa merchant, CEO of Plot Enterprise Ghana Limited
- Waste valorization into added-value food products (use of bioproducts, environmental perspectives, efficiency) (10 minutes)
  Quan Vuong, Senior Lecturer, School of Environmental and Life Sciences, University of Newcastle
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

18.00–20.00

Reception (FAO Eight Floor/Fountain bar)

Thursday, 28 September 2023

THEMATIC SESSIONS 3.1 AND 4.1

Thematic Session 3
Climate change and resilience

9.00–10.30

Session 3.1: Conservation agriculture

Chair:

- Akhylbek Kurishbayev, Rector of the National Agricultural Research University, Kazakhstan

Key panellist:

- Gottlieb Basch, President, European Conservation Agriculture Federation (ECAF)

Rapporteurs:

- Hafiz Muminjanov, Technical Adviser, NSP, FAO
- Haekoo Kim, Technical Adviser, NSP, FAO

- Opening remarks (5 minutes)
- Adopting conservation agriculture: facing the challenges and grasping the opportunities for sustainable agriculture (10 minutes)
  Marie Bartz, Researcher, Centre for Organic and Regenerative Agriculture (CARe-Bio) Brazil
- Small scale mechanization for conservation agriculture (10 minutes)
  Enamul Haque, Adjunct Associate Professor, Murdoch University, Australia; Coordinator of Conservation Agriculture Project Bangladesh
- Innovative agricultural machinery and policies: key drivers of conservation agriculture development
  Hongwen Li, Leader / Professor at the Conservation Tillage Research Center (CTRC), College of Agricultural Engineering, China Agricultural University, Beijing, China
- Drivers for successful validation and scaling of conservation agriculture principles and practices in sub-Saharan Africa (10 minutes)
  Alfred Micheni, Director, Kenya Agricultural and Livestock Research Organization (KALRO-Embu)
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 4
Digitalization and automation

Session 4.1: Digital technology and ICT

Chair:

- Salah Sukkarieh, Professor, Robotics and Intelligent Systems, Sydney University

Key Panellist:

- Maria Gabriela Cruz, Farmer, Member of European Conservation Agriculture Federation (ECAF)

Rapporteurs:

- Santiago Santos-Valle, Agricultural Engineer, FAO
- Vuyo Maphango, Sustainable Agricultural Mechanization Consultant, FAO

- Opening remarks (5 minutes)
- Low-cost internet of things devices along with information and communication technology can help irrigation decisions for smallholder farmers (10 minutes)
  Clémence Uwamutarambirwa, master's student Seed Potato Fund, Catholic University of Rwanda
- ICT and telematics – its role in supporting the future of on-demand service and automation of smallholder farm assets (10 minutes)
  Jehiel Oliver, CEO, Hello Tractor
- Digital technologies and the use of ICT can empower smallholder farmers to boost their yield and increase their income (10 minutes)
  Worlali Senyo and Princess Anita Asabere, Farmerline, Country Manager Ghana
- "Agricultural digital twins" are the next step in digital technology and have the potential to provide individualized information and suggestions for smallholder farmers (10 minutes)
  Simon van Mourik, Researcher, Wageningen University and Research
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

10.30–11.00

Break

THEMATIC SESSIONS 3.2 AND 4.2

Thematic session 3
Climate change and resilience

11.00–12.30

Session 3.2: Precision agriculture

Chair:

- Mohammad Esmaeil Asadi, Senior Research Scientist, Golestan Agricultural and Natural Resources Research and Education Center, Gorgan, Islamic Republic of IranKey panellist:
- Theodor Friedrich, Conservation Agriculture Expert, former FAO staff member

Rapporteurs:

- Hafiz Muminjanov, Technical Adviser, NSP, FAO
- Haekoo Kim, Technical Adviser, NSP, FAO

- Opening remarks
- Integrating precision agriculture technologies in conservation agriculture: enhancing sustainability and resource efficiency (10 minutes)
  Liudmila Orlova, Chair of the National Movement on Conservation Agriculture, Russian Federation
- Precision nutrient management in conservation agriculture: optimizing fertilizer use for sustainable crop production (10 minutes)
  Hamza Rkha Chaham, Co-founder Chief Operating Officer, SOWIT, Morocco
- Optimizing seed coulters for no-till direct seeding (10 minutes)
  Maik Freitag, Sales and Product Manager Novac
- Precision irrigation management for water conservation in conservation agriculture: tools and strategies (10 minutes)
  Itamar Nadav, Head of R&D and Innovation, Agronomy Department, Netafim Italia
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 4
Digitalization and automation

Session 4.2: Automation and artificial intelligence

Chair:

- Cornelia Weltzien, Professor, Department of Agromechatronics, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany

Key panellist:

- Jelle Filip Van Loon, Associate Program Director for Sustainable Agrifood systems, Latin America, CIMMYT

Rapporteurs:

- Santiago Santos-Valle, Agricultural Engineer, FAO
- Vuyo Maphango, Sustainable Agricultural Mechanization Consultant, FAO

- Opening remarks
- Artificial Intelligence and smart app technologies can provide scalable and automated plant health advice to farmers around the world (10 minutes)
  Simone Strey, CEO, Plantix
- The automation of precision-spray applications with artificial intelligence support can deliver crop protection from drones for smallholder farmers in a scalable and robust manner (10 minutes)
  Justin Gong, Co-founder, XAG Company
- Training the next generation of farmers in the use of digital technologies and information and communication technologies is important for the inclusive adoption drone technologies (10 minutes)
  Tawanda J. Chihambakwe, Director at Precision Aerial Group, Flying Labs
- Experiences and learnings of an agricultural robotic and artificial intelligence startup in Latin America (10 minutes)
  Leo Carvalho, Chief Global Strategy Officer, Solinftec, Brazil
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

12.30–14.00

Lunch break

Side event: Voices of young people for sustainable mechanization and digitalization

THEMATIC SESSIONS 5.1 AND 6.1

Thematic session 5
Supply chain and standards

14.00–15.30

Session 5.1: Supply chains and services

Chair:

- Ignacio Ruiz, ANSEMAT, General Secretary; Agrievolution Alliance, President

Key panellist:

- Saruth Chan, Undersecretary of State, Ministry of Agriculture, Forestry and Fisheries, Cambodia

Rapporteurs:

- Godfrey Omulo, Agricultural Engineer Consultant, FAO
- Shangchuan Jiang, Project Manager, NSP, FAO

- Opening remarks (5 minutes)
- Major trends and opportunities in agricultural mechanization supply chains (10 minutes)
  Charlie O'Brien, Secretary General, Agrievolution
- Overcoming constraints in spare-parts supply and machinery maintenance services (10 minutes)
  Yahia Khalifa, CLAAS Marketing responsible for Africa and the Near East
- Business models for mechanization supply-chain integration (10 minutes)
  Tie Li, Chairman, CAMCO
- The Mining, Agriculture and Construction Equipment Protocol: an international framework for asset-based financing of equipment (10 minutes)
  Priscila Andrade, Legal Officer, UNIDROIT
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 5
Supply chain and standards

14:00–15:30

Session 5.1: Supply chains and services

Chair:

- Ignacio Ruiz, ANSEMAT, General Secretary; Agrievolution Alliance, President

Key panellist:

- Saruth Chan, Undersecretary of State, Ministry of Agriculture, Forestry and Fisheries, Cambodia

Rapporteurs:

- Godfrey Omulo, Agricultural Engineer Consultant, FAO
- Shangchuan Jiang, Project Manager, NSP, FAO

- Opening remarks (5 minutes)
- Major trends and opportunities in agricultural mechanization supply chains (10 minutes)
  Charlie O'Brien, Secretary General, Agrievolution
- Overcoming constraints in spare parts supply and machinery maintenance services (10 minutes)
  Yahia Khalifa, CLAAS Marketing responsible for Africa and Near East
- Business models for mechanization supply chain integration (10 minutes)
  Tie Li, Chairman, CAMCO
- MAC protocol: international framework for asset-based financing of equipment (mining, agriculture, and construction) (10 minutes)
  Priscila Andrade, Legal Officer, UNIDROIT
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 6
Business models and multistakeholder engagement

Session 6.1: Inclusive business models

Chair:

- Saidi Mkomwa, Executive Secretary and Chief Executive Officer, African Conservation Tillage Network

Key Panellist:

- Maartje Pronk, Business Development Manager Asia; IDE, Bangladesh

Rapporteurs:

- Mayling Flores-Rojas, Agricultural Engineer, FAO
- Vuyo Maphango, Sustainable Agricultural Mechanization Consultant, FAO

- Opening remarks (5 minutes)
- Enhancing partnership with smallholder farmers, dealers, and financial institutions in agricultural mechanization (10 minutes)
  Paul Christopher Richards, CEO, AgLeaseCo, Zambia
- Inclusive business models: sustainable agricultural mechanization in Kenya (10 minutes)
  Joshua Irungu, County Government of Laikipia, Kenya
- Business model for women to access agricultural mechanization (10 minutes)
  Minli Yang, Professor, College of Engineering, China Agricultural University; Director, China Research Center for Agricultural Mechanization Development
- Emerging mechanization business models (10 minutes)
  Hujjat Nadarajah, CEO, Tun Yat
- Panel discussion and Q&A (40 min)
- Concluding remarks

15.30–16.00

Break

THEMATIC SESSIONS 5.2 AND 6.2

Thematic session 5
Integrated pest management

16.00–17.30

Session 5.2: Regulations and standards

Chair:

- Anshuman Varma, Deputy-Head, United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Centre for Sustainable Agricultural Mechanization (CSAM)

Key panellist:

- Sandro Liberatori, Machinery Standards Specialist, UN-ANTAM, Terni, Italy

Rapporteurs:

- Godfrey Omulo, Agricultural Engineer Consultant, FAO
- Shangchuan Jiang, Project Manager, NSP, FAO

- Opening remarks (5 minutes)
- Benefits of standards (operator safety, efficiency and reduction of food loss, harmonization, trade enhancement, networking among testing stations) (10 minutes)
  Julia Nielson, Deputy Director, Trade and Agriculture (OECD)
- Newly established testing stations perspective on standards and regulations; challenges and needs (10 minutes)
  Shreemat Shrestha, Chief, National Agricultural Engineering Research Centre, Nepal Agricultural Research Council; Vice-chair ANTAM 2023
- Agriculture machinery regulations and standards: extension services, capacity building and farmers' needs (including gender perspectives) (10 minutes)
  Margaret Mangheni, Professor for Extension, Makerere University, Uganda
- Benefits of standardization for safety; robotics and innovation; regulations and subsidization for decarbonization and reduction of toxic substances (10 minutes)
  Shyam Narayan Jha, Deputy Director-General, Indian Council of Agricultural Research, Department of Agricultural Research & Education, Ministry of Agriculture and Farmers' Welfare, New Delhi
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Thematic session 6
Business Models and multistakeholder engagement

Session 6.2: Multistakeholder engagement

Chair:

- Hiroyuki Takeshima, Senior Research Fellow, Development Strategy and Governance Division, International Food Policy Research Institute (IFPRI)

Key panellist:

- Sunita Nhemaphuki, Chair, R&D Innovative Solution, Kathmandu, Nepal

Rapporteurs:

- Mayling Flores-Rojas, Agricultural Engineer, FAO
- Vuyo Maphango, Sustainable Agricultural Mechanization Consultant, FAO

- Opening remarks (5 minutes)
- Partnership for the development of agricultural mechanization (10 minutes)
  Marco Silvestri, Programme Officer, United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Centre for Sustainable Agricultural Mechanization (CSAM)
- Creating sustainable institutions and long-term vision frameworks (10 minutes)
  El Hassane Bourarach, Technical Adviser, Sustainable Agricultural Mechanization Pillar, African Conservation Tillage Network, Africa
- Multistakeholder engagement for promoting growth of mechanization professionals and instilling public trust (10 minutes)
  Lawrence Gumbe, Chairperson of the Kenya Society of Environmental, Biological and Agricultural Engineer (KeSEBAE)
- How to influence gender-sensitive policies in the domain of sustainable mechanization (10 minutes)
  Yamuna Ghale, Senior Research Fellow, Institute for Integrated Development Studies
- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

Friday, 29 September 2023

THEMATIC SESSIONS 7

Thematic session 7
Enabling environment

Moderator: **Beth Bechdol**, Deputy Director-General, FAO

9.00–10.30

Chair:

- Geoffrey Mrema, Professor, Sokoine University, United Republic of Tanzania

Co-chair:

- Tom Goddard, Former Senior Government Advisor, Sustainable Land Development, Alberta, Canada

Key panellist:

- Renata Bueno Miranda, Secretary of Innovation, Sustainable Development, Irrigation and Cooperativism, Ministry of Agriculture, Livestock, and Food Supply (MAPA), Brazil

Rapporteurs:

- Josef Kienzle, Agricultural Engineer, FAO
- Joseph Mpagalile, Agricultural Engineer, FAO

- Opening remarks (5 minutes)
- Enabling sustainable agricultural mechanization through farmer-led initiatives and collaboration (10 minutes)
  Arianna Giuliodori, Arnold Puech d'Alissac, President, World Farmers' Organization (WFO)
- Transforming agriculture in Africa: farmer organization-driven strategies for an enabling environment in sustainable agricultural mechanization (10 minutes)
  Gerald Masila, Executive Director; Eastern Africa Grain Council (EACG)
- Governments' role in enabling sustainable agricultural mechanization for economic growth and food sustainability in Zimbabwe: a case study (10 minutes)
  Edwin Zimunga, Chief Director, Agricultural Engineering, Mechanization and Soil Conservation
- Government role in enabling sustainable agricultural mechanization for economic growth and food sustainability in the Philippines: a case study (10 minutes)
  Rossana Marie C. Amongo, Dean, Agricultural Machinery Division, Institute of Agricultural Engineering, College of Engineering and AgroIndustrial Technology; University of the Philippines
- Fostering an enabling environment for sustainable agricultural mechanization from the perspective of supply chain actors (10 minutes)
  Vanessa Stiffler-Claus, Vice President International Policy and Strategy, John Deere
- Agricultural mechanization systems (10 minutes)
  Zhenxing Xu, Deputy Director, Centre of Agricultural Machinery Development and Extension, Ministry of Agriculture and Rural Affairs (MARA), China

Friday, 29 September 2023

- Panel discussion and Q&A (40 min)
- Concluding remarks (5 minutes)

10.30–11.00

Break

11.00–12.30

PLENARY SESSION 2: REPORTS ON THEMATIC SESSIONS AND CONFERENCE RECOMMENDATIONS

Moderator: **Josse De Baerdemaeker**, Professor, KU Leuven

Reports on thematic sessions

- Introduction
- Highlights from each thematic session by chairperson or co-chairperson from seven thematic sessions

Conference recommendations

- Presentation of call to action by GAMC Secretariat/Organizing Committee (10 minutes)
- Discussions and conclusion(40 minutes)

12.30–14.00

Lunch break

14.00–15.30

PLENARY SESSION 3: HIGH-LEVEL SEGMENT AND CLOSING

Moderator: **Beth Bechdol**, Deputy Director-General, FAO

High-level segment

- H.E. Mohan Priyadarshana De Silva, Honourable State Minister of Agriculture, Colombo, Sri Lanka
- Ms Renata Bueno Miranda, Secretary of Innovation, Sustainable Development, Irrigation and Cooperativism, Ministry of Agriculture and Livestock (MAPA), Brazil
- Mr Alpisbay Tolibaev, Head of Department/ Doctor of Technical Sciences, Ministry of Agriculture, Uzbekistan
- Mr Eric Renaud, Director-General of National Society of Agricultural Mechanization (SoNaMA), Benin
- Discussion (20 Minutes)

Closing remarks

QU Dongyu, Director-General, FAO (10 minutes)

CONTACTS

For more information visit:
www.fao.org/events/detail/global-conference-on-sustainable-agricultural-mechanization/en
or contact us at:

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This publication represents the proceedings of the Global Conference on Sustainable Agricultural Mechanization that FAO organized in a hybrid format from 27 to 29 September 2023.

FAO convened the conference to provide a neutral forum for its Members, farmers, scientists, development agencies, policymakers, civil society, private-sector representatives and other stakeholders to discuss how to promote sustainable agricultural mechanization to support the development of sustainable agrifood systems.

The proceedings provide a record of the main highlights of the conference, including the opening and keynote address plenary sessions, a high-level segment and seven parallel sessions dedicated to the conference theme of "Efficiency, Inclusiveness and Resilience".

The conference was timely, informative, inclusive and inspiring and developed a call to action composed of 15 points that prioritize the way forward for collective action to develop and deliver solutions.

Sustainable agricultural mechanization is facilitated by the development of farmer-centric solutions, promoting access by all farmers to new and emerging technologies, facilitated by enabling policies and benefiting from strategic international and national partnerships.

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