



This book is provided in digital form with the permission of the rightsholder as part of a Google project to make the world's books discoverable online.

The rightsholder has graciously given you the freedom to download all pages of this book. No additional commercial or other uses have been granted.

Please note that all copyrights remain reserved.

About Google Books

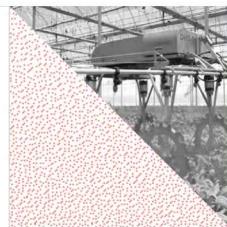
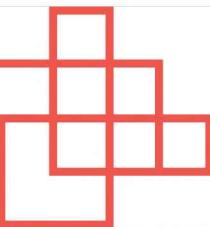
Google's mission is to organize the world's information and to make it universally accessible and useful. Google Books helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



Food and Agriculture
Organization of the
United Nations

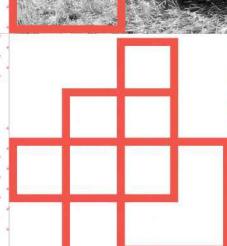
SUSTAINABLE AGRICULTURAL MECHANIZATION IN CHINA

A COMPREHENSIVE REVIEW



**FAO
INVESTMENT
CENTRE**

**COUNTRY
INVESTMENT
HIGHLIGHTS**



SUSTAINABLE AGRICULTURAL MECHANIZATION IN CHINA A COMPREHENSIVE REVIEW

Minli Yang
China Agricultural University

Shangchuan Jiang
Food and Agriculture Organization of the
United Nations

Required citation:

Yang, M. & Jiang, S. 2023. *Sustainable agricultural mechanization in China – A comprehensive review*.

FAO Investment Centre Country Investment Highlights No. 21. Rome. FAO.

<https://doi.org/10.4060/cc2867en>

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

ISBN 978-92-5-137172-5

© FAO, 2023



Some rights reserved. This work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; <https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode>).

Under the terms of this licence, this work may be copied, redistributed and adapted for non-commercial purposes, provided that the work is appropriately cited. In any use of this work, there should be no suggestion that FAO endorses any specific organization, products or services. The use of the FAO logo is not permitted. If the work is adapted, then it must be licensed under the same or equivalent Creative Commons license. If a translation of this work is created, it must include the following disclaimer along with the required citation: "This translation was not created by the Food and Agriculture Organization of the United Nations (FAO). FAO is not responsible for the content or accuracy of this translation. The original English edition shall be the authoritative edition."

Disputes arising under the licence that cannot be settled amicably will be resolved by mediation and arbitration as described in Article 8 of the licence except as otherwise provided herein. The applicable mediation rules will be the mediation rules of the World Intellectual Property Organization <http://www.wipo.int/amc/en/mediation/rules> and any arbitration will be in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law (UNCITRAL).

Third-party materials. Users wishing to reuse material from this work that is attributed to a third party, such as tables, figures or images, are responsible for determining whether permission is needed for that reuse and for obtaining permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

Sales, rights and licensing. FAO information products are available on the FAO website (www.fao.org/publications) and can be purchased through publications-sales@fao.org. Requests for commercial use should be submitted via: www.fao.org/contact-us/licence-request. Queries regarding rights and licensing should be submitted to: copyright@fao.org.

Cover photographs:

© Golden Datian Technology Co.,Ltd./Keming Wu

© Shanghai Dahui Agricultural Machinery Equipment Co., Ltd.

© Chongqing Shineray Agricultural Machinery Co., Ltd./Qiming Cheng

© Weichai Lovol Heavy Industry Co., Ltd./Bingxue Li

Contents

Foreword	XI
Acknowledgements	XIII
Abbreviations and acronyms	XIV
Executive summary	XVII
INTRODUCTION	1
CHAPTER 1	
Current status of sustainable agricultural mechanization in China	7
1.1 Improved quality and standardization of agricultural machinery contribute to decreasing emissions and controlling pollution	8
1.2 Increased level of agricultural mechanization plays a positive role in agricultural labour transfer and economic prosperity	13
1.3 Enhanced capability in technological innovations, research and development (R&D) and manufacturing of machinery support the development of sustainable agricultural mechanization	14
1.4 Wide applications of green and environmentally friendly mechanization technology and equipment promote the modernization of green agriculture	19
1.5 Sustainable mechanization hire service systems and development of farmers' cooperatives increase agricultural productivity and farmers' income and livelihoods	20
1.6 Well-organized agricultural machinery management, extension service systems, and information technology improve the capacity of public service	31
1.7 Sustainable agricultural mechanization in mountainous and hilly areas provides support for the prosperity of the agricultural industry and poverty reduction	31
1.8 Summary	35
CHAPTER 2	
Main practices and experiences	37
2.1 Great support provided by the Chinese Government	37
2.2 A complete system of laws, regulations and policies for agricultural mechanization	38
2.3 Special funds to support agricultural machinery purchase subsidies and operation subsidies set up by the central government and provincial governments	41
2.4 Agricultural machinery and equipment technology innovation, extension and application	46
2.5 Capacity development for agricultural mechanization hire service providers and organizations	51
2.6 Follow-up on the quality investigation and supervision of agricultural machinery and equipment	59
2.7 The contributions of agricultural mechanization to agricultural production, food security and employment during and after COVID-19	59
CHAPTER 3	
Challenges	67
3.1 Challenges in agricultural machinery R&D and manufacturing	67
3.2 Challenges in the promotion and application of agricultural mechanization	69
3.3 Challenges in the public management of agricultural mechanization	69
3.4 Challenges in the human resources of agricultural machinery hire services	69
3.5 Challenges in land management scale and agricultural machinery use efficiency	70

CHAPTER 4		
Opportunities and main trends		73
4.1 Opportunities		73
4.2 Main trends		74
CHAPTER 5		
Development goal and path		77
5.1 Main goals for 2025		77
5.2 Long-term goals for 2035		78
5.3 Development path		78
CHAPTER 6		
Development focus and directions		83
6.1 Prioritizing the development of whole-process mechanization of main crop production		83
6.2 Optimizing mechanized production of cash crops		84
6.3 Accelerating mechanization in hilly and mountainous areas		86
6.4 Promoting the mechanization of livestock management and aquaculture		86
6.5 Promoting the mechanization of storage and processing		87
6.6 Development of “mechanization + digitalization” innovations		88
6.7 Strengthening international cooperation and learning from international experience		89
CHAPTER 7		
Investment and policy recommendations		97
7.1 Increasing financial support and investment		97
7.2 Promoting technological innovations of agricultural mechanization		98
7.3 Strengthening the modernization of agricultural mechanization and machinery management services		99
7.4 Promoting innovations of the agricultural mechanization extension service system		100
7.5 Strengthening the industrial cluster, industrial chain and agricultural hire services		101
7.6 Strengthening human resources for sustainable agricultural mechanization		102
7.7 Deepening international cooperation and exchanges		103
CHAPTER 8		
Business models and case studies of sustainable agricultural mechanization hire services in China		105
8.1 Business models of sustainable agricultural mechanization hire services in China		105
8.2 Case studies of sustainable agricultural mechanization business models in China		109
CHAPTER 9		
Perspectives		121
9.1 The whole-process mechanized production of crops		122
9.2 Significantly strengthening the mechanization of livestock management, aquaculture and fisheries		122
9.3 Achieving whole-process mechanized production in various agricultural regions		123
9.4 Significantly enhancing the added value of agricultural products through mechanization in protected agriculture		124
9.5 Mechanization and digitalization innovations will be extensively adopted in agricultural mechanization management, monitoring and services		125
9.6 Demonstration cases of future farms in China		125
9.7 Strengthening international exchanges and cooperation to achieve win-win development		125
REFERENCES		133

Tables, figures and boxes

Tables

1	Change in the total power of agricultural machinery in China from 2000 to 2019	9
2	Change in tractor numbers in China from 2000 to 2019	10
3	Change in plant protection mechanization level and numbers of plant protection machinery and equipment in China from 2010 to 2019	11
4	Annual number (sets) of main agricultural machinery subsidized after the upgrading of engines under stage III standards	11
5	Statistics on the comprehensive mechanization level of crop production and harvesting in China (2000–2019)	12
6	Comprehensive mechanization level (%) of tillage, seeding/planting, and harvesting in China (2010–2019)	12
7	Comprehensive mechanization level of production and harvesting of staple crops from 2010 to 2019 (%)	13
8	Mechanization level (%) of tillage, sowing/planting, and harvesting, and comprehensive mechanization level (%) of staple crops in China in 2019	14
9	Output of main agricultural machinery products of backbone manufacturers in China in 2020	18
10	Statistical data on pesticide application and mechanization level from 2010 to 2019	19
11	Changes in agricultural mechanization hire service organizations and agricultural households with machinery in China from 2008 to 2019	23
12	Expected values of China's agricultural mechanization development goals in 2025 and 2035	78

Figures

1	Change trend of total power of agricultural machinery in China from 2000 to 2019	8
2	Changes in rice transplanter numbers from 2000 to 2019	15
3	Changes in the quantity of maize combine harvesters from 2001 to 2019	15
4	Changes in maize combine harvesters, self-propelled harvesters and knapsack harvesters from 2006 to 2019	16
5	Key demand and innovation chain of intelligent agricultural machinery and equipment industry	17
6	Suitable-for-mechanization transformation of circulated land, before (left) and after (right), Zhanghong ecological agriculture co., Ltd., Tongnan, Chongqing	33
7	Suitable-for-mechanization transformation of circulated land, before (left) and after (right), Hongmei family farm, Santai, Sichuan	33
8	Research flow of the project “integration and demonstration of key mechanization technology in the whole process of moderate-scale production of staple crops in hilly and mountainous areas”, China Research Centre for Agricultural Mechanization Development, China Agricultural University	34
9	Constructing moderate-scale and whole-process mechanized production system of wheat and maize in hilly areas	34

10	Schematic diagram of the framework of China's system of laws and regulations for agricultural mechanization	39
11	Changes from 1998 to 2019 in the annual amount of subsidies for the purchase of agricultural machinery from the central government fund	41
12	Sustainable agricultural mechanization (SAM) supports agricultural production during and after the COVID-19 crisis	63
13	Framework of agricultural mechanization production technology system based on the integration of mechanization and agronomy and integration of mechanization and digitalization	79
14	Development path of sustainable agricultural mechanization in China	80
15	Upstream and downstream markets of agricultural mechanization hire service and its contributions	106
16	Agricultural mechanization hire service and and its relationship with related factors	106
17	Agricultural mechanization hire service business model 1	107
18	Agricultural mechanization hire service business model 2	108
19	Agricultural mechanization hire service business model 3	108

Boxes

1	Explanation of main terms in this report	21
2	Training for grassroots agricultural machinery personnel and chairpersons of agricultural mechanization cooperatives	24
3	Beijing Xingnong Tianli Agricultural Mechanization Specialized Service Cooperative, Beijing	25
4	Mengbin Gelan Farmers' Cooperative Specialized in Pig Production and Marketing in Lancang County, Yunnan Province	26
5	Jiangsu Runguo Agricultural Development Co., Ltd., Jiangsu Province	27
6	Hongmei Family Farm in Santai County, Sichuan Province	28
7	Minda Specialized Planting Cooperative in Jialing District, Nanchong City, Sichuan Province	29
8	Axiang Agricultural Mechanization Specialized Service Cooperative in Longshan County, Hunan Province	30
9	What happens in a “suitable for mechanization” transformation in hilly and mountainous areas?	32
10	Suitable-for-mechanization transformation in hilly and mountainous areas in Shanxi Province	45
11	Suitable-for-mechanization transformation in hilly and mountainous areas in Hunan Province	46
12	Suitable-for-mechanization transformation in hilly and mountainous areas in Chongqing	47
13	The First China Agricultural Machinery Extension Field Day and Mechanization Technology Training Workshop (2016)	48
14	China Agricultural Machinery Extension Field Day and Mechanization Technology Training Workshop in 2017	49

15	Field Day in 2018 themed Promoting the Whole-Process Mechanization of Agricultural Production	50
16	China Agricultural Machinery Extension Field Day and Mechanization Technology Training Workshop in 2019	51
17	China Agricultural Intelligent Machinery and Equipment Field Day and Mechanization Technology Training Workshop in 2020 (on site and virtual event)	52
18	Field Meeting on Unmanned Agricultural Machinery Operation, Beijing, 2021	53
19	Agricultural Machinery Promotion Field Day in Hebei Province in 2021	54
20	Yunnan Sugarcane Production Mechanization and Machinery Extension Field Day in 2019	55
21	Mechanization technology of Straw Returning for Protected Agriculture Field Day in Shandong Province, 2019	56
22	Demonstration event for the mechanized operation for production of fruit, tea, mulberry and hemp in the hilly and mountainous areas in South China, 2018	57
23	The Conference on the Establishment of Cooperative Chairperson Working Committee of College Graduate Practitioners and the Signing Ceremony of the Strategic Cooperation Framework Agreement	58
24	Rice whole-process mechanized production and digital management platform	110
25	Industry-Academia Integration and Sustainable Agricultural Mechanization Supporting Targeted Poverty Alleviation activity	112
26	Ms Jiang Minglan and plant protection drones	113
27	Ms Sheng Guangning and plant protection drones	114
28	Haibin Agricultural Mechanization Specialized Cooperative in Liyang City, Jiangsu Province	115
29	Yongfu Agricultural Machinery Cooperative, Anzhou District, Mianyang City, Sichuan Province	116
30	Dudu Operation Online Platform of the “New Farmer • Work Together” internet of things (IoT) System	118
31	The practice of Beidahuang Jiansanjiang–Country Garden Unmanned Farm Project	126
32	Exploration and practice of unmanned farms by South China Agricultural University	128
33	Bayer, Jifei Technology (XAG), and Rural Taobao (Alibaba) jointly launched the “Sustainable Farming Programme”	130





Foreword

The People's Republic of China faced significant challenges in meeting the food requirements for one-fifth of the world's population. Yet, over the past four decades, China has managed to reduce poverty, achieve food security and become the largest agricultural economy in the world.

However, China still faces many agriculture and rural development challenges.

In the drive to achieve the UN Sustainable Development Goals (SDGs), China is adopting ambitious "green growth" agriculture policies, strategies, institutional frameworks and technologies. The World Bank and the Food and Agriculture Organization of the United Nations (FAO) are engaging with China's green growth agrifood transformation through supporting better policies and better investments.

From 2020 to 2022, a Programmatic Advisory Service and Analytics (PASA) project on "Transforming Rural China: Greening Agricultural Modernization" was undertaken by the World Bank. The project aligns with the World Bank's Country Partnership Framework and FAO Country Programming Framework in China. The objective of the PASA was to demonstrate how existing rural development pathways, alongside the farming policies and strategies, can be reoriented to accelerate progress towards greener agricultural development in China.

With the rapid development of industrialization and urbanization in China, much of the rural labour force has shifted to urban areas. Consequently, the traditional modes of agricultural production and organization must be transformed.

Sustainable agricultural mechanization is a vital component of agricultural modernization. The FAO, the World Bank, and other international organizations are promoting sustainable agricultural mechanization in China through a series of projects and collaborations with stakeholders.

Sustainable agricultural mechanization is an approach to achieving agricultural and rural development which is not only profitable and inclusive for smallholder farmers and community members, but also minimizes the risk of environmental damage, while building resilience to the impacts of climate change. The approach covers technological, economic, social, environmental, and cultural aspects, which together are vital to achieving sustainable development in the agrifood sector.

China's extensive experience in sustainable agricultural mechanization provides valuable insights and learnings for countries globally, particularly for developing countries. Drawing on this wealth of experience, the World Bank China Office, the FAO Plant Production and Protection Division and the FAO Investment Centre have joined forces to develop this pivotal publication. Experts at FAO, the Centre for Sustainable Agricultural Mechanization (CSAM) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and other institutions also provided important inputs and review comments. It is one of a three-part Country Investment Highlights series on China, under FAO Investment Centre Knowledge for Investment (K4I).

This publication provides a timely overview of sustainable agricultural mechanization in China. It covers China's experiences, practices and business models, and provides investment and policy recommendations to enable China to reach the goal of agricultural and rural modernization by 2035. These efforts

empower smallholder farmers to modernize their agricultural practices, and to promote sustainable development.

We are confident this publication will inspire governments and decision-makers in international and national financing institutions, as well as other donors and development partners, to take a fresh look at how supporting sustainable agricultural mechanization can galvanize rural transformation.

Jingyuan Xia
Director
Plant Production and
Protection Division
FAO



Mohamed Manssouri
Director
FAO Investment Centre



Acknowledgements

This publication is the result of a collaboration between the World Bank and the Food and Agriculture Organization of the United Nations (FAO), as part of the World Bank's Programmatic Advisory Services and Analytics (PASA) project on Transforming Rural China: Greening Agricultural Modernization (ID: P171518). The PASA was led by Ladisy Komba Chengula (Lead Agriculture Economist, the World Bank, China office). Over the course of 2021, the PASA produced 16 policy and technical working papers which were prepared by experts from leading Chinese universities and scientific centers and experts from FAO, the International Food Policy Research Institute, and external universities.

As one of the technical working papers, this publication was developed by Minli Yang (Director and Professor, China Research Centre for Agricultural Mechanization Development, China Agricultural University) and Shangchuan Jiang (Associate Professional Officer/Agriculture Specialist, Plant Production and Protection Division – NSP, FAO).

The authors thank Ladisy Komba Chengula for his overall leadership of the study and both Ladisy Komba Chengula and Josef Kienzle (Agricultural Engineer, NSP, FAO) for their coordination and valuable advice for this publication, as well as their contributions to the long-term collaboration between FAO and the World Bank. The authors wish also to thank Luigi Baldassari, Clare O'Farrell, Davide Garavoglia and Sonia Malpeso at FAO Investment Centre for their support to this publication.

The authors acknowledge the valuable review comments from Donald F. Larson (Independent Researcher, International Institute for Development and Environmental Studies), Theodor Friedrich (former FAO Representative of the Plurinational State of Bolivia and the Republic of Cuba), Yutong Li (Head, Centre for Sustainable Agricultural Mechanization – CSAM, UNESCAP), Anshuman Varma (Deputy Head/Programme Officer, CSAM, UNESCAP), Qiang Li (National Programme Officer, CSAM, UNESCAP), Yuee Feng (Programme Coordinator, CSAM, UNESCAP), and William R. Sutton (Global Lead for Climate-Smart Agriculture and Lead Agricultural Economist, the World Bank).

The authors thank the graduate students at China Agricultural University, including Jifeng Pan, Xiang Zhang and Pengfei Ji, for their support in information collection and/or translation from Chinese into English. The authors thank stakeholders for providing the photos.

The authors wish to express their gratitude to Jingyuan Xia (Director, NSP, FAO), Mohamed Manssouri (Director, FAO Investment Centre), John Preissing (Deputy Director, FAO Investment Centre), Benoit Bosquet (Regional Director, Sustainable Development, East Asia and Pacific Region, the World Bank), Dina Umal-Duininger (Practice Manager, Agriculture and Food, East Asia and Pacific Region, the World Bank), Fenton Beed (Senior Agricultural Officer, NSP, FAO), Hafiz Muminjanov (Technical Adviser, NSP, FAO), Haekoo Kim (Technical Adviser, NSP, FAO), Mirko Montuori (Communication Officer, NSP, FAO), Takayuki Hagiwara (Regional Programme Leader, Regional Office for Asia and the Pacific, FAO), Xueming Liu (Senior Investment Support Officer, FAO Investment Centre), Yunqing Tian and Xiaonan Bai (Program Assistant, the World Bank), etc. Furthermore, we would also like to thank FAO China, the World Bank China and all national stakeholders for their support to this publication.

The publication was produced by FAO Investment Centre. Its editing was undertaken by Emma Tanner and Bill Hardy, the proofreading by Emma Tanner, and the layout was designed and implemented by Adriana Brunetti and Karen Mata Luna.

Abbreviations and acronyms

5G	fifth generation of mobile technology
AI	artificial intelligence
ANTAM	Asian and Pacific Network for Testing of Agricultural Machinery
AUC	African Union Commission
CAP	Common Agricultural Policy
CEMA	European Agricultural Machinery Association
CIMMYT	International Maize and Wheat Improvement Center
CNY	Chinese yuan
CSAM	Centre for Sustainable Agricultural Mechanization
CVT	continuously variable transmissions
ECAF	European Conservation Agriculture Federation
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
GW	gigawatt
ha	hectare
ICT	information and communication technology
IoT	internet of things
ITU	International Telecommunication Union
kW	kilowatt
MARA	Ministry of Agriculture and Rural Affairs of the People's Republic of China
MEE	Ministry of Ecology and Environment of the People's Republic of China
MIIT	Ministry of Industry and Information Technology of the People's Republic of China
MOF	Ministry of Finance of the People's Republic of China
mu	traditional unit of land area in China (1 mu is about 1/15 hectare)
NO _x	nitrogen oxide
PPP	public–private partnerships
QR code	quick response code
R&D	research and development
SAM	sustainable agricultural mechanization
SAMR	State Administration for Market Regulation of China
SMEs	small- and medium-sized enterprises
UAV	unmanned aerial vehicle
WFP	World Food Programme



Executive summary

INTRODUCTION

Agricultural mechanization is an important symbol and main component of agricultural modernization, and a leading factor in the process. The Chinese Government attaches great importance to the development of agriculture and agricultural mechanization, promotes the transformation of agricultural production and organizational methods, strengthens policy support and industry guidance, greatly supports the extension and application of green and sustainable mechanization technologies, and continuously improves the agricultural ecological environment to achieve sustainable development.

This report strives to comprehensively and systematically summarize the state of China's sustainable agricultural mechanization (SAM) development. The report considers the impacts, experiences and practices, and business models of sustainable agricultural mechanization, as well as the related investment and policy recommendations involved in reaching the goal of agricultural and rural modernization by 2035, driving smallholders to engage in modern agriculture, and achieving sustainable development. The development of sustainable agricultural mechanization in China provides experiences for the world, especially for developing countries.

CURRENT STATUS OF SUSTAINABLE AGRICULTURAL MECHANIZATION IN CHINA

Improved quality and standardization of agricultural machinery contribute to reducing emissions and controlling pollution. The total power of agricultural machinery has increased to 1.028 billion kilowatts. The number of tractors has increased to 22.243 million units. The number of plant protection unmanned aerial vehicles (UAVs) has reached 39 626 units. The number of units of energy-saving, green and eco-friendly agricultural machinery and equipment has increased steadily. The emission standards for agricultural machinery engines will be upgraded from Stage III to Stage IV in December 2022.

Increased levels of agricultural mechanization play a positive role in agricultural labour transfer and economic prosperity. In 2019, the overall mechanization level of crop production and harvesting in China exceeded 70 percent. The whole-process mechanization of major crop production has accelerated.

Enhanced capabilities in technological innovation, research and development (R&D) and manufacturing of agricultural machinery, and wide application of green and environmentally friendly mechanization technology and equipment. From 2016 to 2020, the Chinese Central Government allocated about Chinese yuan (CNY) 980 million to support 11 agricultural mechanization research task directions. The mechanization level of plant protection in 2019 was 4.65 percent higher than in 2015, and mechanized plant protection has contributed to a 51 percent reduction in the use of pesticides. The comprehensive utilization rate of livestock and poultry manure in China has reached 75 percent, and the rate of supporting manure treatment facilities and equipment for large-scale farms has reached 95 percent. The application of mechanized technologies such as conservation agriculture and black soil conservation, straw returning, and plastic agricultural film recovery has been accelerated.

Sustainable agricultural mechanization hire service systems and the development of farmers' cooperatives increase agricultural productivity and farmers' income and livelihoods. The agricultural mechanization hire service providers make use of order services, land trusteeships, land transfers and other systems to achieve large-scale operations. Hire services in China, led by 74 000 agricultural mechanization cooperatives and nearly 200 000 agricultural mechanization hire service organizations, have significantly increased agricultural productivity for smallholders. New business models have been adopted in mechanization hire services.

Well-organized agricultural machinery management, extension service systems and information technology improve the capacity of public services. The agricultural machinery management and extension system has been optimized at national, provincial and city/county levels. The platform for a pilot scheme for subsidized national agricultural machinery purchases has been established. These factors have significantly enhanced the efficiency of policy implementation.

Promoting mechanization in hilly and mountainous areas provides technical support for the prosperity of the agricultural industry and contributes to poverty reduction. The hilly and mountainous areas in China are important production bases for fruit, vegetable, tea, grain and oil crops. The Chinese Government requires that consolidation and expansion of poverty alleviation achievements should play an effective role in rural revitalization. The Ministry of Agriculture and Rural Affairs (MARA) has selected and released farmland that is suitable for transformation through mechanization. The equipment needed for the development of special agricultural product industries in impoverished hilly and mountainous areas will be included in the scope of national subsidies.

MAIN PRACTICE AND EXPERIENCE

The Chinese Government attaches great importance and provides support to the development of agricultural mechanization. A complete system of laws, regulations and policies for agricultural mechanization has been established. **The central government and provincial governments set up special funds** for subsidies to support agricultural machinery purchase, weak links in operations, and mechanized subsoiling operations; and to implement well-facilitated high-standard farmland construction and the "suitable for mechanization" transformation of farmland in hilly and mountainous areas. The technological innovation and application of agricultural machinery and equipment has been significantly promoted. Intelligent agricultural machinery and equipment are included in the national key research and development (R&D) plan.

Capacity development for agricultural mechanization hire service providers and organizations. Capacity development for new business entities for agricultural mechanization services has been conducted, and a new agricultural mechanization hire service system is being established. The mechanism for mechanization hire services is improving, and hire services will be continuously upgraded. College graduates and other agricultural talents with higher education are encouraged to engage in agricultural mechanization hire services.

Follow-up quality investigation and supervision of agricultural machinery and equipment. The Ministry of Agriculture and Rural Affairs (MARA) is in charge of the national quality investigation of agricultural machinery products, and the administrative departments of agricultural mechanization in the people's

governments at provincial level are responsible for the quality investigation work within its administrative area. Investigation has promoted the quality improvement of machinery and equipment.

Agricultural mechanization plays a critical role in restoring agricultural production, guaranteeing food security and promoting employment during and post COVID-19. Agricultural mechanization supports agricultural production and cross-regional harvesting operations during and post the COVID-19 pandemic. Agricultural mechanization has played an important role in restoring agricultural production and ensuring food security. Agricultural mechanization in 2020 had some remarkable characteristics, namely in the areas of online production preparation, hire services, intelligent equipment and green technology. The cross-regional mechanization operation for harvesting has effectively alleviated the shortage of equipment in some areas, and has made important contributions to ensuring harvesting and food security. During the COVID-19 pandemic, MARA organized agricultural research and extension institutes to carry out online and field training. Public-private partnerships (PPPs), agricultural machinery investment and inputs, technical support and mechanization hire services are essential to the restoration of agricultural production. Mechanization hire services meet the needs of farmers of different scales, especially small-scale farmers; intelligent agricultural machinery and information and communication technologies (ICTs) have further improved the efficiency of agricultural mechanization services.

CHALLENGES

Challenges in agricultural machinery R&D and manufacturing. Compared with developed countries, there are still big gaps in aspects of key machinery technology, parts, materials and manufacturing processes, and major equipment. The production capacity of middle- and low-end products is excessive and production is highly homogenized. The leading role of enterprises has not yet emerged. The effective supply of some products is insufficient. Domestic tractors are mainly small- and medium-horsepower with mechanical shifting. The overcapacity of agricultural machinery production coexists with gaps, and the adaptability and reliability of machinery products need to be improved.

Challenges in the promotion and application of agricultural mechanization. The mechanization development of paddy fields in South China is slow, especially in the hilly and mountainous areas in Southwest China. The level of mechanization is relatively low in key links of cash crop production, as well as in animal husbandry, fisheries, primary processing of agricultural products, and protected agriculture. Integration between agricultural mechanization and agronomy is low. Agricultural machinery operations, maintenance, storage and other infrastructure are still unsophisticated.

Challenges in the public management of agricultural mechanization. Although some information service platforms and management systems have been established, there are problems such as inconsistent standards for platform construction, and difficulties in data sharing. The agricultural machinery circulation service network is not complete enough.

Challenges in human resources in agricultural machinery hire services. There is a serious shortage of practical and skilled personnel at the grassroots level with an urgent need for a large number of agricultural personnel in the fields of

agricultural machinery technology, innovative management, service and technical consulting.

Challenges in land management scale and agricultural machinery utilization efficiency. Small-scale farmers will continue to be the mainstay of agricultural production in China. In the future, it is estimated that the proportion of large-scale farmers will only be about 5 percent of all the farmers in China.

OPPORTUNITIES AND MAIN TRENDS

Opportunities

Accelerate the process of agricultural and rural modernization and implement the rural revitalization strategy. As China accelerates the transfer of the agricultural labour force, there is an urgent need to replace human and animal labour with agricultural mechanization. **The agricultural machinery industry has entered the stage of high-quality development.** The scientific and technological innovation capability continues to improve in the agricultural machinery and equipment industry. The popularization of informatization, intelligent machinery and digital technology is accelerating. The independent controllability of the supply chain and industrial chain is continuously being enhanced, which lays the material and equipment foundation to meet the needs of mechanization in various fields.

Main trends

Take innovation as the driving force to make up for shortcomings. Promote the innovations in extension of agricultural mechanization technology, mechanization hire services and management systems. Constantly improve the level of agricultural machinery R&D and manufacturing. Strengthen the weak links in agricultural machinery, whole-process mechanized production, and mechanization of hilly and mountainous areas.

Promote mechanization along the agrifood value chain and develop from all aspects. Systematically plan the whole-process mechanization of the production of major crops and breeding varieties. Integrate and match the varieties, cultivation methods, land, and machinery. Establish a technical system for whole-process mechanization for the overall development of mechanization at industrial and regional level. **Government strategy and market-led development.** Continue to improve the supporting policies for agricultural mechanization, advance the reform of management systems and mechanisms, enhance the supply of public services, stimulate the vitality of market entities, and constantly improve the service quality and efficiency of agricultural mechanization operations. **System concept and green development.** In light of local conditions, enhance the coordination of agricultural machinery, agronomy, farmland and agricultural operation modes. The integration of mechanization, digitalization and artificial intelligence (AI) technology is being strengthened. The green development of mechanization in China is realizing unification in development quality, structure, scale, speed, effectiveness, safety, and ecological sustainability.

DEVELOPMENT OBJECTIVE AND PATH

Main objective by 2025. By 2025, the total power of agricultural machinery in the country will be stable at about 1.1 billion kilowatts (kWs). The comprehensive mechanization rate of crop production and harvesting will reach 75 percent nationwide, and 55 percent in hilly and mountainous areas (e.g. counties, cities

or districts), respectively. The overall mechanization rate of protected agriculture, animal husbandry, aquaculture and primary processing of agricultural products will reach more than 50 percent. Agricultural mechanization industrial clusters and industrial chains will be further consolidated, and total revenue from agricultural machinery services will exceed CNY 500 billion.

Long-term goals for 2035. By 2035, agricultural production will be mostly mechanized. The whole-process production of major crops in China will be mechanized, and the level of mechanization of livestock, aquaculture and fisheries will be significantly increased. Mechanization of protected agriculture and primary processing of agricultural products will significantly enhance the value-added capabilities of agricultural products. An efficient mechanized production system will be established. The model **mechanization + digitalization** will be fully applied to agricultural mechanization management, operation monitoring and services, and mechanization will comprehensively support all agricultural and rural modernization.

Development path. Focusing on the goal of agricultural and rural modernization, enhance the research and development of intelligent agricultural machinery equipment and key core technologies. Promote the integration of the agricultural industry, education, research and marketing; strengthen the construction of national technological innovation centres or engineering centres for digital agriculture and intelligent machinery; and explore the pilot projects of unmanned farms, pastures and fishing grounds. Promote the adaption of mechanization to mixed farming, intelligent information technology, agricultural operations and management, and well-facilitated farmland construction. Establish a sustainable mechanization technology system based on the integration of mechanization and agronomy as well as digitalization. The scientific and technological, institutional and policy innovations will drive the development of high-quality and high-efficiency agricultural mechanization systems. It will further ensure the effective supply of important agricultural products, and accelerate the development of agricultural industries in impoverished areas, thus supporting agricultural and rural modernization and revitalization.

DEVELOPMENT FOCUS AND FUTURE DIRECTIONS

Prioritize the development of whole-process mechanization of staple crop production. Strengthen the weak link in whole-process mechanization of crop production in key areas, establish a green and efficient mechanized production technology system, reduce losses and improve quality.

Improve the mechanized production of cash crops. Improve the mechanized production levels of main cash crops, make breakthroughs in mechanization of the key production links of special cash crops, and promote the mechanization development of protected agriculture and protected cultivation.

Accelerate mechanization in hilly and mountainous areas. Accelerate the R&D and application of suitable agricultural machinery and equipment in hilly and mountainous areas, promote the “suitable for mechanization” transformation of farmland, and promote the institutional innovation of agricultural production and management. Actively develop innovative business models for hire services such as “new business entity + appropriate scale + whole-process mechanization + integrated agricultural service centre”, and “new business entity + appropriate scale + ICT-based mechanization hire services”.

Promote the mechanization of livestock, poultry, aquaculture and fisheries.

Promote green and efficient farming equipment and technology. Promote the development of ecological circulation models supporting integrated crop-livestock systems and mixed farming. Promote the upgrading of technology and equipment, and promote energy saving and consumption reduction of machinery and equipment for livestock, poultry, aquaculture and fisheries.

Improve the mechanization of the primary processing of agricultural products.

Coordinate and promote the mechanization of primary processing of agricultural products in various agricultural industries and links. Focus on value-added processing, and promote the R&D, manufacturing, extension and application of key technologies and equipment (e.g. energy-saving and eco-friendly grading, and cold chain logistics). Promote the integrated application of mechanization technology for the primary processing of agricultural products. Focus on the quality improvement, loss reduction and efficiency of post-harvesting agricultural products. Establish the mechanization technology system of primary processing of agricultural products.

Innovative development of “mechanization + digitalization”. Promote technological innovation in intelligent agricultural machinery and equipment, demonstrate the use of intelligent technologies, and promote digital management of mechanized production. Establish a mechanized production system based on digital agriculture and explore unmanned farm system solutions that can be replicable and scaled up.

Strengthen international cooperation and learn from international experience.

Drawing experience from international practice will optimize China's agricultural machinery quality testing system. The emission standard Stage IV in China is equivalent to, and even more stringent than, the European Union Stage IIIB standards, which is in line with the national goal to develop new types of green and efficient machinery and equipment, and to promote high-quality and efficient agricultural development. It is of great significance for greening agricultural modernization.

China will continue to strengthen international communication and cooperation through South-South and Triangular Cooperation (SSTC) and collaboration with international organizations to share the sustainable agricultural mechanization experience with developing countries and contribute to solving the challenges of food security and poverty reduction in the world.

INVESTMENT AND POLICY RECOMMENDATIONS

Further increase financial support and investment

Consistently implement the agricultural machinery purchase subsidy policy. Focus on supporting weak links, the application and extension of green and efficient machinery and equipment, intelligent agricultural machinery and information technology equipment. Implement subsidy pilots for the purchase of innovative machinery products, apply comprehensive subsidies for agricultural machinery purchases, and promote the replacement of scrapped agricultural machinery. Vigorously implement major projects such as subsidies for mechanized operations of subsoiling and land preparation, and the *Action Plan for Conservation Agriculture of Black Soil in Northeast China (2020–2025)* (MARA and MOF, 2020). Promote the transformation of farmland that is suitable for mechanization. Innovate financial and insurance services for agricultural

machinery, increase the scale of credit guarantees, implement discount interest rates on loans, and launch pilot programmes for comprehensive agricultural machinery insurance.

Investment is needed in strengthening infrastructure construction for mechanization, transformation of scientific and technological achievements in agricultural machinery, quality testing standards and extension of agricultural machinery, capacity development, and awareness raising of different stakeholders. It is crucial to optimize financial services and improve the subsidy system and enabling policies.

Promote technological innovation in agricultural mechanization

Strengthen overall coordination. Strengthen demand-side guidance for agricultural machinery and equipment, and organize the formulation of agricultural mechanization technology and an equipment demand catalogue. Guide scientific research institutes and agricultural machinery enterprises to focus on strengthening the missing links or weak links in agricultural machinery.

Improve the innovation system. Strengthen the construction of the scientific research bases for whole-process mechanization, promote the in-depth integration of production, education and research for agricultural machinery, and improve the R&D capabilities of core technologies and equipment. Establish innovation centres of agricultural machinery manufacturing. In addition, establish a market-oriented mechanism for selecting innovation directions, and a risk-sharing and benefit-sharing mechanism that encourages innovation.

Increase fiscal and taxation support. Support the R&D of key generic technologies for machinery and equipment and intelligent manufacturing. Implement preferential tax policies so that enterprises will benefit from the preferential policies for income tax. Imported parts and raw materials for agricultural machinery and equipment will benefit from import tax preferences.

Innovate financial support methods. Establish a diversified investment and financing system for modern design and manufacturing of agricultural machinery and equipment. Encourage the establishment of various market-oriented development funds, and encourage social capital to invest in the modern design and manufacturing of agricultural machinery and equipment.

Strengthen modernization of agricultural mechanization and machinery management services

Establish a national management and service platform for agricultural machinery and equipment, led by the Ministry of Agriculture and Rural Affairs (MARA). The platform will coordinate the modernization development of agricultural machinery management and services, including the management and service subplatforms for agricultural machinery data analysis, remote monitoring of mechanization operations, machinery supervision, hire services, machinery markets, and other aspects.

Promote the application of intelligent monitoring terminals for agricultural machinery. Strengthen the extension and application of intelligent agricultural machinery monitoring terminals, in order to provide reliable, complete and continuous data for the agricultural machinery operation and maintenance management platform. Encourage enterprises, universities and research institutes to cooperate and jointly develop intelligent agricultural machinery

detection terminals and systems. Additionally, promote the practical application of intelligent testing terminals for machinery through policy guidance.

Establish and optimize financial guarantee mechanisms for agricultural machinery management and services. Finance leasing and credit guarantee services for agricultural machinery should be provided to agricultural cooperatives, mechanization hire service enterprises and family farms. In the form of government purchase services, green and environmentally friendly mechanization hire services will be provided for smallholders.

Promote the innovations of agricultural mechanization extension service systems

Establish regional extension centres for modern agricultural machinery. A number of regional modern agricultural machinery extension centres should be established and based in the main bodies of agricultural machinery extension departments and township extension stations. A number of national-level regional agricultural machinery promotion platforms should be established to integrate the product innovation chain and extension of agricultural machinery, and promote the coordinated development of areas such as agricultural machinery R&D, achievement transformation, industry incubation, and financial support.

Establish high-level experimental demonstration bases for the whole-process mechanization of the staple crop production. High-level experimental and demonstration bases for the whole-process mechanization production should be established to explore mechanized production models tailored to local conditions.

Appraisal and extension project on new agricultural machinery products and technologies. Organize appraisers to attend training courses and workshops. Conduct seminars on agricultural machinery extension appraisal technology. Increase publicity efforts for new agricultural machinery products and technologies. Introduce a rating or scoring mechanism. The demander can distinguish the quality of agricultural machinery products more intuitively. Enable the demander to intuitively distinguish the quality of agricultural machinery products.

Establish an online platform for agricultural mechanization technology extension and services. Establish and complete a unified, coordinated, efficient, safe and reliable platform for dynamic information monitoring and service of mechanization operations, to collect and distribute the timely information of operation supply and demand. The platform will provide better agricultural machinery operation and maintenance services for agricultural operation entities, and solve the problems of asymmetry in supply-demand information and poor communication.

Strengthen the industrial cluster, industrial chain and agricultural mechanization hire services

Promote the establishment of the agricultural mechanization industrial chain and supply chain, integrating R&D, manufacturing, extension and application. Promote agricultural mechanization hire services, machinery maintenance and spare parts supply, and capacity development for machinery operations. Promote the innovative service models such as “internet of things + Agricultural Machinery Operation”. Support mechanization hire service providers and organizations in

providing trusteeship services for agricultural production, and facilitate the integration of smallholders into modern agricultural development.

Demonstration of agricultural mechanization hire service entities to improve service quality and efficiency. Support 1000 agricultural machinery cooperatives nationwide as demonstration cooperatives to provide mechanization hire services along the agrifood value chain and to moderate-scale operations.

Strengthen human resources for sustainable agricultural mechanization

Complete the rotation training of mechanization administrative personnel at all levels within two to three years and build a high-competency leadership team for agricultural mechanization management. Strengthen the independence and controllability of agricultural machinery R&D, the manufacturing supply chain and the industrial chain. Comprehensively cultivate the innovative, application-oriented, interdisciplinary and leading research talents in the field of agricultural machinery. Every year, no fewer than 5 million agricultural machinery operators will be trained.

Deepen international cooperation and exchanges

Conduct extensive international exchanges and cooperation in advanced design technologies, standardization of intelligent manufacturing, establishment of demonstration bases and human resource development. Support domestic and foreign enterprises and industrial organizations to arrange technical exchanges and cooperation to effectively encourage investment, introduce technology and develop capacity of human resources. Encourage multinational companies and foreign R&D institutions to establish agricultural machinery manufacturing, R&D institutions, talent training centres and demonstration factories in China. Encourage domestic enterprises to participate in international mergers and acquisitions (M&A) and acquire shares in advanced foreign enterprises for machinery R&D and manufacturing.

BUSINESS MODELS AND CASE STUDIES OF SUSTAINABLE AGRICULTURAL MECHANIZATION HIRE SERVICES IN CHINA

China is developing new business models for hire services, with agricultural mechanization as a starting point for promoting a new model of industrial development and for leading the diversified development of hire services. Three representative business models are introduced. *Business model 1:* A new agricultural business entity provides centralized mechanized land management or agricultural mechanization hire services for scattered lands (smallholders). *Business model 2:* Agricultural supply and marketing cooperatives provide a unified supply of agricultural inputs (e.g. seeds, pesticides and fertilizer) and acquisition and sales of agricultural products for smallholders, whereas the agricultural mechanization cooperatives provide comprehensive whole-process mechanization hire services for smallholders. *Business model 3:* The industrial business model featured by "whole-process mechanization + integrated agricultural service center" leads the sustainable development of smallholders.

Additionally, the case studies are discussed, including rice whole-process mechanized production and digital management platforms; mechanization in post-harvest, which contributes to poverty alleviation and industrial development in hilly and mountainous areas; agricultural mechanization cooperatives that lead in the development of smallholders to achieve common prosperity through the public-private partnership (PPP) mode; and hire service supply-demand docking platforms based on ICT.

PERSPECTIVES

From the perspective of the development situation of global agricultural modernization and mechanization, modern agriculture is based on mechanization along the value chain, and characterized by appropriate scale, standardization, specialization, digitalization, automation and intelligence. Whole-process mechanization will be achieved in different sectors and in various agricultural regions, with technological, institutional and policy innovations as accelerators. In addition, the added value of agricultural products will be significantly enhanced through mechanization in protected agriculture.

China will realize the integration of mechanization and digitalization in various industrial fields and establish a mechanized production system based on digital agriculture. Smart agriculture scenarios will start to be seen on China's large-scale farms. It is vital to explore unmanned agricultural production systems and unmanned farm system solutions that can be replicated and scaled up, and thus make contributions to global agricultural development and food security.

China adheres to the principles of reform and opening up, actively responds to the Belt and Road Initiative, and adheres to the path of internationalization and sustainable development. This will further accelerate international cooperation in agricultural mechanization and enhance the "bringing in" and "going global" of agricultural mechanization. In the future, international South-South and Triangular Cooperation, as well as cooperation with international organizations such as the Food and Agriculture Organization of the United Nations (FAO), the World Food Programme (WFP), the World Bank, and the Centre for Sustainable Agricultural Mechanization (CSAM), to share China's experiences in sustainable agricultural mechanization with the world and help developing countries tackle the challenges of food security and poverty reduction and improve the sustainability and resilience of the agrifood system.



Introduction

Agricultural mechanization is an important symbol and main component of agricultural modernization, as well as being a leading factor in the process. In seeking agricultural modernization, different countries have chosen different ways of development; however, no matter which way is chosen, the common objective is to solve the challenges in agricultural mechanization.

Over the past few years, China has focused on poverty alleviation and has lifted 55.75 million rural dwellers out of poverty. The problem of absolute poverty, which had plagued the Chinese nation for thousands of years, has been solved in a historic way, creating a miracle in the history of poverty reduction. Agricultural modernization has made steady progress, annual grain output has remained stable at more than 650 million tonnes, and 100 million rural migrants have moved to cities. China's urbanization rate has reached 63.89 percent. China's economy has shifted from the rapid growth stage to high-quality development stage, and the focus of work related to agriculture, rural areas and farmers has entered a new stage of comprehensively promoting rural revitalization and accelerating agricultural and rural modernization. The *Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-Term Goals for 2035* (Xinhua News Agency, 2021a) outlines that priority should be given to developing agriculture and rural areas, promoting rural revitalization, and fundamentally realizing agricultural and rural modernization in China by 2035. Moreover, the law emphasizes promoting rural revitalization with Chinese characteristics; strengthening agriculture-industry and urban-rural linkages; promoting an innovative mode to optimize mutual improvement between industry and agriculture and the mutual complementarity between urban and rural areas; pursuing coordinated development and common prosperity; and accelerating agricultural and rural modernization. China attaches importance to optimizing the quality, efficiency, and competitiveness of agriculture; increasing overall agricultural productivity; strengthening support to agricultural science, technology, and equipment; and ensuring the effective linkage of poverty alleviation achievements and rural revitalization, while at the same time protecting the environment and minimizing pollution. It clearly

emphasizes strengthening research and development (R&D) and extension of large- and medium-sized, intelligent, and complex agricultural machinery, and increasing the overall agricultural mechanization rate to 75 percent for crop production and harvesting. China's government work reports in the past five years have proposed promoting mechanization and innovation in agriculture.

China's population has increased from 540 million in 1949 to 1.4 billion at present (2021) and food consumption has increased substantially. China's population is expected to reach a peak of about 1.45 billion around 2030. The overall demand for food and agricultural products will continue to increase; this represents not only a simple increase in quantity, but also a variety of requirements for quality and safety.

With the rapid development of industrialization and urbanization in China, much of the rural labour force has moved to urban areas. The average age of the agricultural labour force is 46 years. About 67.5 percent of the labour force is from 40 to 60 years old, with only 4.8 percent born in the 1980s. Technology-oriented, business-oriented, and service-oriented skills are inadequate and knowledge and capability in the central and western regions, remote mountainous areas, and poor areas are insufficient. The labour force left in rural areas is represented by women, children, and the elderly. With rural-to-urban migration, those born after 1980 do not want to farm, those born after 1990 do not know how to farm, and those born after 2000 do not care about farming. The questions of "who will farm" and "how to farm" are the challenges faced, a situation in which we must produce more food and agricultural products with a smaller labour force. The traditional modes of agricultural production and organization must be changed. China aims to reach a carbon peak by 2030 and become carbon neutral by 2060. From the perspective of agriculture, it is essential to minimize water use, degradation of soil and biodiversity, environmental pollution and carbon emissions; save seeds, land, water, fertilizer, and pesticides; and constantly improve the agricultural ecological environment, thus achieving green and sustainable development. It is vital to optimize agricultural productivity, output, yield, and resource use; reduce agricultural inputs and costs; improve the quality of agricultural products; and realize more effective agriculture and agricultural mechanization.

Therefore, in order to realize agricultural and rural modernization and implement its rural revitalization strategy, China must accelerate the transformation to sustainability, carbon neutrality, resource conservation and regeneration, and economic efficiency, and put forward higher requirements for agricultural mechanization.

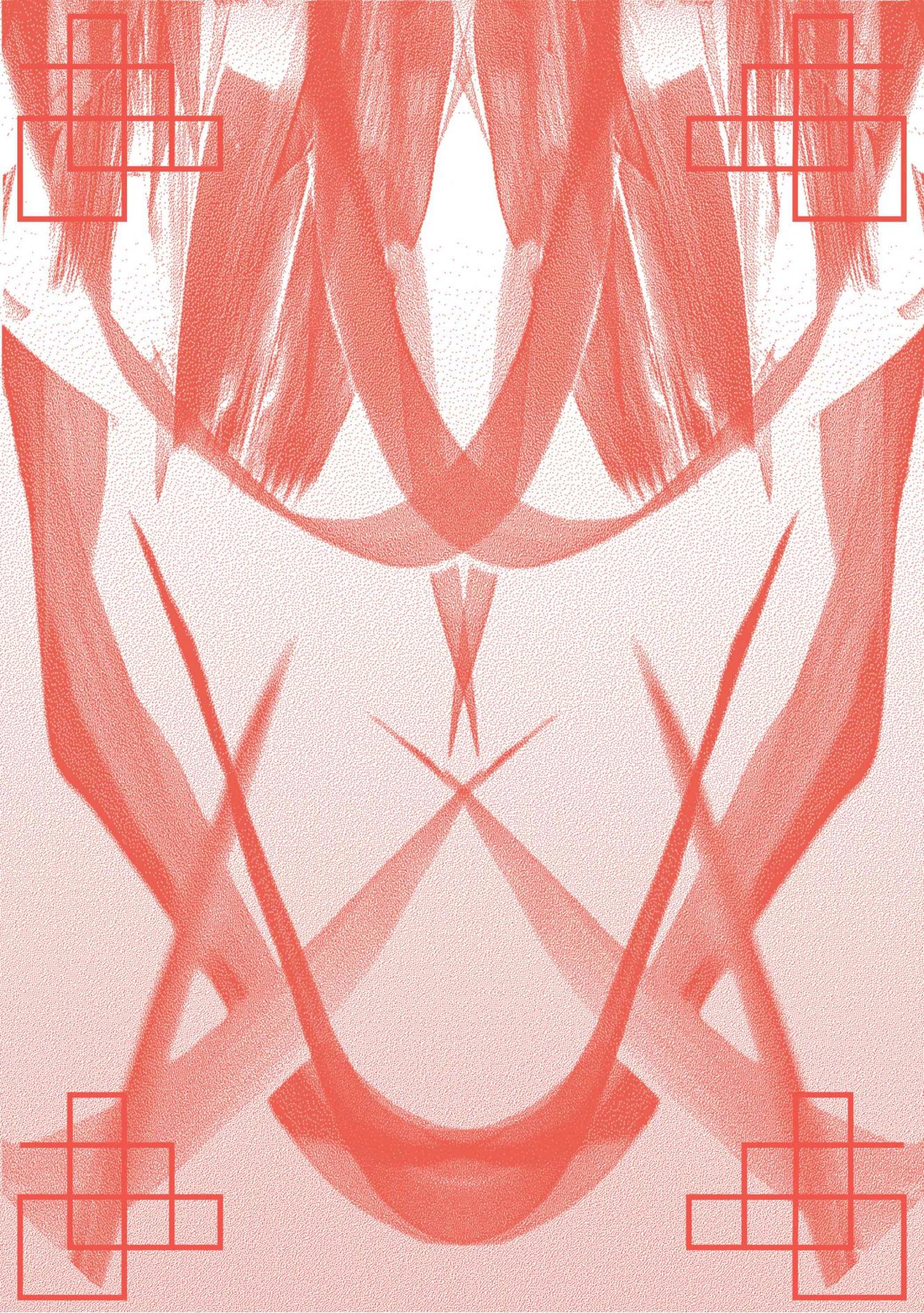
According to the FAO Sustainable Agricultural Mechanization website (FAO, 2022a), sustainable agricultural mechanization covers all levels of farming and processing technologies. Sustainable mechanization is applied to agricultural land preparation, supports timely seeding and planting, weed control, integrated pest management, precise fertilizer application, harvesting, preparation for storage, and value addition operations along the food supply chain in terms of on-farm processing, transport and marketing. Sustainable mechanization is a means to an end. Farmers who have access to improved agricultural tools and powered technologies can shift from subsistence farming to more market-oriented farming, making the agricultural sector more attractive to rural youth. Sustainable mechanization supports the development of food supply chains through improved agricultural practices for increased production and enhanced food security. It eases and reduces hard labour, relieves labour shortages, improves productivity and timeliness of agricultural operations, improves the efficient use of resources, enhances market access and contributes to mitigating

climate-related hazards. Sustainable mechanization considers technological, economic, social, environmental and cultural aspects when contributing to the sustainable development of the food and agricultural sector.

This report strives to comprehensively and systematically summarize the state of China's sustainable agricultural mechanization development. The report considers the impacts, experiences and practices, and business models of sustainable agricultural mechanization, as well as the related investment and policy recommendations involved in reaching the goal of agricultural and rural modernization by 2035, driving smallholders to engage in modern agriculture, and achieving sustainable development. The development of sustainable agricultural mechanization in China provides experiences for the world, especially for developing countries.







Chapter 1

Current status of sustainable agricultural mechanization in China

In general, China's agricultural production has transformed from mainly relying on human and animal power to mainly relying on mechanical power. There have been historic achievements in agricultural mechanization and agricultural production has entered a new stage led by mechanization. This section introduces the development status of agricultural mechanization in China, including that (1) improved quality and standardization of agricultural machinery contribute to decreasing emissions and controlling pollution and improving safety; (2) increased agricultural mechanization plays a positive role in agricultural labour transfer and economic prosperity; (3) enhanced capability in technological innovation, R&D, and manufacturing of agricultural machinery support the development of sustainable agricultural mechanization; (4) widely used green and environmentally friendly mechanization technology and equipment promote the modernization of green agriculture; (5) the sustainable agricultural mechanization hire service system and development of farmers' cooperatives increase agricultural efficiency and farmers' income and livelihoods; (6) well-organized agricultural machinery management, the extension service systems, and information technology improve the capacity of public service; and (7) sustainable agricultural mechanization in mountainous and hilly areas provides technical support for the prosperity of the agricultural industry and poverty alleviation.

1.1 IMPROVED QUALITY AND STANDARDIZATION OF AGRICULTURAL MACHINERY CONTRIBUTE TO DECREASING EMISSIONS AND CONTROLLING POLLUTION

By the end of 2019, the total power of agricultural machinery in China had increased from 429 million kW (429 GW) in 2000 to 1.028 billion kW (1028 GW) (Table 1, Figure 1), an increase of 140 percent. The power of agricultural machinery per hectare (ha) of cultivated land increased from 2.71 kW/ha to 7.01 kW/ha, an increase of nearly 160 percent. The number of tractors per 1000 ha (kha) of cultivated land increased from 106 to 174, an increase of 64 percent. The number of tractors increased from 13.737 million units in 2000 to 22.243 million units in 2019 (Table 2). Among them, large- and medium-sized tractors increased from 0.97 million units in 2000 to 6.701 million units in 2017, an increase of 591 percent. Small-sized tractors increased from 12.767 million units in 2000 to 16.342 million units in 2017, an increase of 28 percent; nevertheless, the annual growth rate was negative and the growth rate is lower than for large- and medium-sized tractors, indicating that the demand and structure of tractors had changed. In 2018, because of the change in the statistical standards for large-, medium-, and small-sized tractors, the data for 2018 were abnormal compared with those of previous years. But, according to the data for 2019, the general trend of development was still the same. The number of units of energy-saving, green, and eco-friendly agricultural machinery and equipment increased steadily as well as the number of large- and medium-sized tractors of more than 80 horsepower. Agricultural aircraft developed rapidly, among which the number of plant protection unmanned aerial vehicles (UAVs) reached 39 626 (units), which is 56.6 times more than in 2014, and the growth rate of UAVs was faster than that of mobile plant protection machinery (Table 3). The elimination of old agricultural machinery (with high energy consumption and low efficiency) will be accelerated.

The national emission standards for agricultural machinery engines have been upgraded from Stage II to Stage III in China. In accordance with the

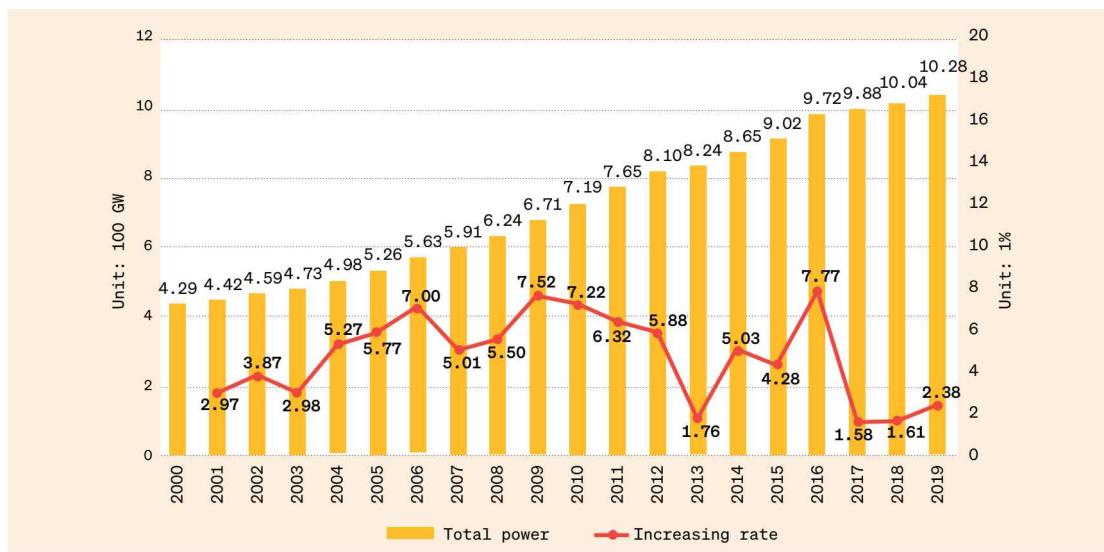


Figure 1
Change trend of total power of agricultural machinery in China from 2000 to 2019

SOURCES: Author's compilation. Data sources from **Department of Agricultural Mechanization Management, MARA**. 2000 National Statistical Annual Report on Agricultural Mechanization. July 2001, and for consecutive years to 2019.

Table 1

Change in the total power of agricultural machinery in China from 2000 to 2019

Year	Total power of agricultural machinery		Agricultural machinery power per ha of cultivated land		Number of tractors per kha of cultivated land	
	Total power (billion kW)	Annual rate of increase (%)	Agricultural machinery power per hectare (kW/ha)	Annual rate of increase (%)	Number of tractors per hectare (units/kha)	Annual rate of increase (%)
2000	0.429	-	2.71	-	106	-
2001	0.442	3.87	2.78	2.58	110	3.77
2002	0.459	2.98	2.88	3.60	111	0.91
2003	0.473	5.27	2.97	3.13	115	3.60
2004	0.498	5.77	3.15	6.06	121	5.22
2005	0.526	7.00	3.32	5.40	129	6.61
2006	0.563	5.01	3.58	7.83	136	5.43
2007	0.591	5.50	3.76	5.03	141	3.68
2008	0.624	7.52	3.98	5.85	155	9.93
2009	0.671	2.97	4.13	3.77	155	0
2010	0.719	7.22	4.44	7.51	161	3.87
2011	0.765	6.32	4.74	6.76	167	3.73
2012	0.810	5.88	5.05	6.54	169	1.20
2013	0.824	1.76	5.16	2.18	169	0
2014	0.865	5.03	5.44	5.43	170	0.59
2015	0.902	4.28	5.71	4.96	171	0.59
2016	0.972	7.77	6.23	9.11	172	0.58
2017	0.988	1.58	6.34	1.77	171	-0.58
2018	1.004	1.61	6.48	2.21	166	-2.92
2019	1.028	2.38	7.01	8.18	174	4.82

SOURCES: Department of Agricultural Mechanization Management, MARA. 2000 National Statistical Annual Report on Agricultural Mechanization. July 2001, and for consecutive years to 2019.

requirements of the *Law on the Prevention and Control of Atmospheric Pollution of the People's Republic of China* (adopted in 1987) and the *Air Pollution Prevention and Control Action Plan* (promulgated in 2013), the limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (CHINA III, IV) [GB20891-2014] (MEE, 2014) was implemented. Since December 2016, the emission standards for agricultural diesel engines have been upgraded from Stage II to Stage III. The agricultural machinery diesel engines sold in the market must meet the requirements of the Stage III standards, whereas tractors and combine harvesters that do not meet the standard requirements are prohibited from production and sale and cannot benefit from agricultural machinery purchase subsidies. From January 2017 to the end of December 2020, more and more machinery and equipment was fitted with engines under national Stage III standards, including 125 300 new tractors, 75 500 new wheat combine harvesters, 254 800 new rice combine harvesters, and 147 600 new maize combine harvesters (Table 4). This has played an important role in decreasing carbon emissions, reducing environmental pollution, improving the ecological environment, and advancing green development.

Table 2
Change in tractor numbers in China from 2000 to 2019

Year	Tractor total number		Large- and medium-sized tractors		Small-sized tractors	
	Quantity (million units)	Annual rate of increase (%)	Quantity (million units)	Annual rate of increase (%)	Quantity (million units)	Annual rate of increase (%)
2000	13.737	-	0.970	-	12.767	-
2001	14.346	4.43	1.121	15.57	13.225	3.59
2002	14.461	0.80	0.904	-19.36	13.557	2.51
2003	14.941	3.32	0.973	7.63	13.968	3.03
2004	15.668	4.87	1.116	14.70	14.680	5.10
2005	16.665	6.36	1.396	25.09	15.398	4.89
2006	17.397	4.39	1.676	20.06	15.607	1.36
2007	18.254	4.93	2.048	22.20	16.295	4.41
2008	20.219	10.76	2.995	46.24	17.224	5.70
2009	21.025	3.99	3.516	17.40	17.509	1.65
2010	21.780	3.59	3.922	11.55	17.858	1.99
2011	22.519	3.39	4.407	12.37	18.113	1.43
2012	22.825	1.36	4.852	10.10	17.972	-0.78
2013	22.793	-0.14	5.270	8.62	17.523	-2.50
2014	22.977	0.81	5.680	7.78	17.298	-1.28
2015	23.104	0.55	6.073	6.93	17.030	-1.54
2016	23.170	0.29	6.454	6.27	16.716	-1.84
2017	23.043	-0.55	6.701	3.83	16.342	-2.24
2018	22.403	-2.78	4.220	-37.03*	18.183	11.27
2019	22.243	-0.71	4.439	5.20	17.804	-2.08

SOURCES: Department of Agricultural Mechanization Management, MARA. 2000 National Statistical Annual Report on Agricultural Mechanization. July 2001, and for consecutive years to 2019.

*data in 2018 is abnormal because of the change in the statistical standards for large-, medium-, and small-sized tractors.

The national emission standards of agricultural machinery engines will be upgraded from Stage III to Stage IV in China. On 29 December 2020, the Ministry of Ecology and Environment (MEE) of China published the Announcement on the Issuance of National Environmental Protection Standards: Technical Policy for the Emission Control of Pollutants from Non-Road Diesel Mobile Machinery (HJ1014-2020) (MEE, 2020). Starting from 1 December 2022, all manufactured, imported, and sold non-road mobile machinery under 560 kW (including 560 kW), as well as diesel engines being installed, must meet the requirements of this standard. This standard adopts the technical content for diesel engines for non-road mobile machinery as set out in Directive 97/68/EC (as of revision 2012/46/EU) of the European Parliament and of the Council on 16 December 1997, on the approximation of the laws of the member states relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery. The standard also adopts the technical content of the Pollutant Limits in non-road machinery in the Fifth Stage of European Non-Road Regulation (EU) 2016/1628 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulation (EU)

Table 3

Change in plant protection mechanization level and numbers of plant protection machinery and equipment in China from 2010 to 2019

Year	Mechanization level of plant protection		Number of motorized plant protection machinery		Power of motorized plant protection machinery		Number of plant protection drones	
	Level (%)	Annual rate of increase (%)	Quantity (ten thousand units)	Annual rate of increase (%)	Power (10 000 kW)	Annual rate of increase (%)	Quantity (ten thousand units)	Annual rate of increase (%)
2010	36.17	-	461.44	-	827.33	-	-	-
2011	37.24	1.07	518.08	12.27	893.40	7.99	-	-
2012	38.65	1.41	544.31	5.06	962.75	7.76	-	-
2013	39.16	0.51	559.19	2.73	970.99	0.86	-	-
2014	39.75	0.59	614.04	9.81	1078.63	11.09	0.07	-
2015	40.32	0.57	618.85	0.78	1071.60	-0.65	0.23	228.57
2016	41.00	0.68	629.69	1.75	1110.40	3.62	0.65	182.61
2017	41.97	0.97	618.32	-1.81	1143.07	2.94	1.40	115.38
2018	43.38	1.41	615.26	-0.49	1177.63	3.02	3.15	125.00
2019	44.97	1.59	621.00	0.93	1226.08	4.11	3.96	25.71

SOURCES: National Bureau of Statistics. 2011 China Statistical Yearbook. Beijing:

China Statistics Press, September 2011, and for consecutive years to 2020;

Department of Agricultural Mechanization Administration, MARA. 2010 National Statistical Annual Report on Agricultural Mechanization. July 2011, and for consecutive years to 2019.

Note: According to MARA, motorized plant protection machinery refers to plant protection machinery operated by its own power or supporting power machinery, such as electric sprayers, power sprayers, boom sprayers and air-assisted sprayers.

Table 4

Annual number (sets) of main agricultural machinery subsidized after the upgrading of engines under stage III standards

Year	Wheeled tractor	Wheat combine harvester	Rice combine harvester	Maize combine harvester
2020	445 341	19 157	67 031	43 599
2019	294 472	15 407	52 191	35 823
2018	243 409	16 060	60 117	33 776
2017	270 251	24 913	75 503	34 408
Total	1 253 473	75 537	254 842	147 606

SOURCES: Nongji360. 2017. 2017 Agricultural machinery purchase subsidy system in provinces and cities across China. Cited 30 May 2021. <http://butie.nongji360.com/2017/supervise>; and for consecutive years to 2020. Nongji360. 2020 Agricultural machinery purchase subsidy system for provinces and cities across China. Cited 30 May 2021. <http://butie.nongji360.com/2020/public/supervise>

Table 5

Statistics on the comprehensive mechanization level of crop production and harvesting in China (2000–2019)

Year	Comprehensive mechanization level of crop production and harvesting (%)	Annual increase (percentage points)	Year	Comprehensive mechanization level of crop production and harvesting (%)	Annual increase (percentage points)
2000	32.30	–	2010	52.28	3.15
2001	32.18	-0.12	2011	54.82	2.54
2002	32.35	0.17	2012	57.17	2.35
2003	33.48	1.13	2013	59.48	2.31
2004	34.32	0.84	2014	61.60	2.12
2005	35.93	1.61	2015	63.82	2.22
2006	39.29	3.36	2016	65.19	1.37
2007	42.47	3.18	2017	67.23	2.04
2008	45.85	3.38	2018	69.10	1.87
2009	49.13	3.28	2019	70.02	0.92

SOURCES: Department of Agricultural Mechanization Management, MARA. 2000 National Statistical Annual Report on Agricultural Mechanization. July 2001, and for consecutive years to 2019.

Table 6

Comprehensive mechanization level (%) of tillage, seeding/planting, and harvesting in China (2010–2019)

Year	Comprehensive mechanization level	Mechanized tillage level	Mechanized seeding/planting level	Mechanized harvesting level
2010	52.28	69.61	43.04	38.41
2011	54.82	72.29	44.93	41.41
2012	57.17	74.11	47.37	44.40
2013	59.48	75.99	48.78	48.15
2014	61.60	77.48	50.75	51.29
2015	63.82	80.43	52.08	53.40
2016	65.19	81.40	52.76	56.01
2017	67.23	82.99	54.97	58.47
2018	69.10	84.03	56.93	61.39
2019	70.02	85.22	57.30	62.46

SOURCES: Department of Agricultural Mechanization Administration, MARA. 2010 National Statistical Annual Report on Agricultural Mechanization. July 2011, and for consecutive years to 2019.

Table 7

Comprehensive mechanization level of production and harvesting of staple crops from 2010 to 2019 (%)

Comprehensive mechanization level of production and harvesting of grain crops (%)						Comprehensive mechanization level of production and harvesting of other crops (%)			
Year	Crops	Wheat	Rice	Maize	Potato	Soybean	Rapeseed	Peanut	Cotton
2010	52.28	91.26	60.51	65.94	26.59	73.18	26.08	38.45	51.03
2011	54.82	92.62	65.07	71.56	32.25	69.81	29.05	42.96	53.88
2012	57.17	93.21	68.82	74.95	34.20	63.20	35.44	46.06	59.59
2013	59.48	93.71	71.14	79.76	37.34	62.93	39.18	50.79	61.06
2014	61.60	94.09	76.00	81.12	36.53	62.71	40.48	47.39	70.66
2015	63.82	93.66	78.12	81.21	39.96	65.85	46.85	51.22	66.81
2016	65.19	94.15	79.20	83.08	40.69	72.06	49.55	52.14	69.77
2017	67.23	95.10	80.18	85.55	38.43	84.72	51.55	52.28	70.74
2018	69.10	95.89	81.91	88.31	42.61	84.10	53.94	59.38	76.88
2019	70.02	96.36	83.73	88.95	46.55	85.52	56.88	60.63	81.18

SOURCES: Department of Agricultural Mechanization Administration, MARA. 2010 National Statistical Annual Report on Agricultural Mechanization. July 2011, and for consecutive years to 2019.

No.1024/2012 and (EU) No.167/2013, and amending and repealing Directive 97/68/EC (European Union, 2016). Agricultural machinery (e.g. tractors and combine harvesters), forestry machinery, machinery for fisheries (e.g. aerators and pond excavators), water pumps, and others must comply with the technical standards.

This will play a critical role in further decreasing carbon emissions, improving the farmland ecological environment, and contributing to the greening of agricultural modernization.

1.2 INCREASED LEVEL OF AGRICULTURAL MECHANIZATION PLAYS A POSITIVE ROLE IN AGRICULTURAL LABOUR TRANSFER AND ECONOMIC PROSPERITY

In 2019, the overall mechanization level of crop production and harvesting exceeded 70 percent, an increase of 37.7 percentage points over 2000 (Table 5). Mechanized tillage, mechanized seeding/planting, and mechanized harvesting reached 85.22 percent, 57.30 percent, and 62.46 percent, respectively, which is an increase of 15.61, 14.26, and 24.05 percentage points over 2010, respectively (Table 6).

The whole-process mechanization of all staple crop production has accelerated significantly. In 2019, the comprehensive mechanization level of wheat, maize, rice, and potatoes reached 96.36 percent, 83.73 percent, 88.95 percent, and 46.55 percent, respectively. The comprehensive mechanization level of planting and harvesting of soybeans, rapeseed, peanuts, and cotton reached 85.52 percent, 56.88 percent, 60.63 percent, and 81.18 percent, respectively (Table 7). The mechanization level of each link of staple crop production and harvesting has also developed rapidly (Table 8). The number of rice transplanters increased from 44 500 units in 2000 to 906 600 units in 2019, more than 20 times higher than that in 2000 (Figure 2). The number of maize combine harvesters increased from 3700 units in 2000 to 558 300 units in 2019, which was 151 times higher than in 2000 (Figure 3). The number of self-propelled maize harvesters increased rapidly, reaching 460 200 units in 2019, which accounted for 82.43 percent of the maize harvesters, and was 4.69 times higher than the number of backpack maize harvesters (Figure 4). A total of 614 demonstration counties for whole-process mechanization have been established.

Table 8

Mechanization level (%) of tillage, sowing/planting, and harvesting, and comprehensive mechanization level (%) of staple crops in China in 2019

Crop type	Mechanized tillage level	Mechanized sowing level	Mechanized harvesting level	Comprehensive mechanization level of production and harvesting
Crops	85.22	57.30	62.46	70.02
Wheat	99.81	90.88	96.29	96.36
Rice	98.84	53.89	93.43	83.73
Maize	97.77	88.81	77.32	88.95
Potato	74.68	27.80	27.78	46.55
Soybean	88.21	86.55	80.89	85.52
Rapeseed	84.80	32.54	44.00	56.88
Peanut	77.36	52.91	46.05	60.63
Cotton	99.34	88.04	50.13	81.18

SOURCE: **Department of Agricultural Mechanization Administration, MARA.** 2020. *2019 National Statistical Annual Report on Agricultural Mechanization*.

The mechanization rate has increased steadily for animal husbandry and aquaculture, protected agriculture, primary processing of agricultural products, as well as fruit, vegetable, and tea production and harvesting.

According to the China Research Centre for Agricultural Mechanization Development at China Agricultural University, from 2003 to 2019, for every 1 percentage point increase in the comprehensive mechanization level of crop production and harvest in China, the urbanization rate will increase by 0.53 percentage points and the proportion of employees in the primary industry to the employees of the whole society will decrease by 0.64 percentage points. The development of agricultural mechanization has enabled more people to be released from a heavy workload and to engage in decent jobs, promoted the development of primary industries and tertiary industries, and promoted national economic prosperity.

According to relevant data, in 2018 the average livestock inventory number was 155 head for dairy farms (households) in China, among which intensive dairy farms (with more than 100 head of livestock) accounted for 61.4 percent; and the mechanized milking rate on large-scale farms reached more than 90 percent (Xinhua News Agency, 2020). The milking machines include bucket type, mobile type, pipe type, milking hall (table) and other types. Additionally, large-scale layer hen farms adopt a completely closed feeding system and they have mostly achieved mechanized egg collection.

1.3 ENHANCED CAPABILITY IN TECHNOLOGICAL INNOVATIONS, RESEARCH AND DEVELOPMENT (R&D) AND MANUFACTURING OF MACHINERY SUPPORT THE DEVELOPMENT OF SUSTAINABLE AGRICULTURAL MECHANIZATION

According to statistics in 2017, there were 67 agricultural machinery research institutions at all levels in China, including 24 national and provincial research institutions on agricultural machinery. There are 62 national agricultural machinery testing and appraisal institutions, including 32 at the national and provincial level. There are 2519 agricultural mechanization technology extension institutions at all levels, including 35 at the national and provincial levels. According to incomplete statistics, nearly 60 agricultural colleges/universities

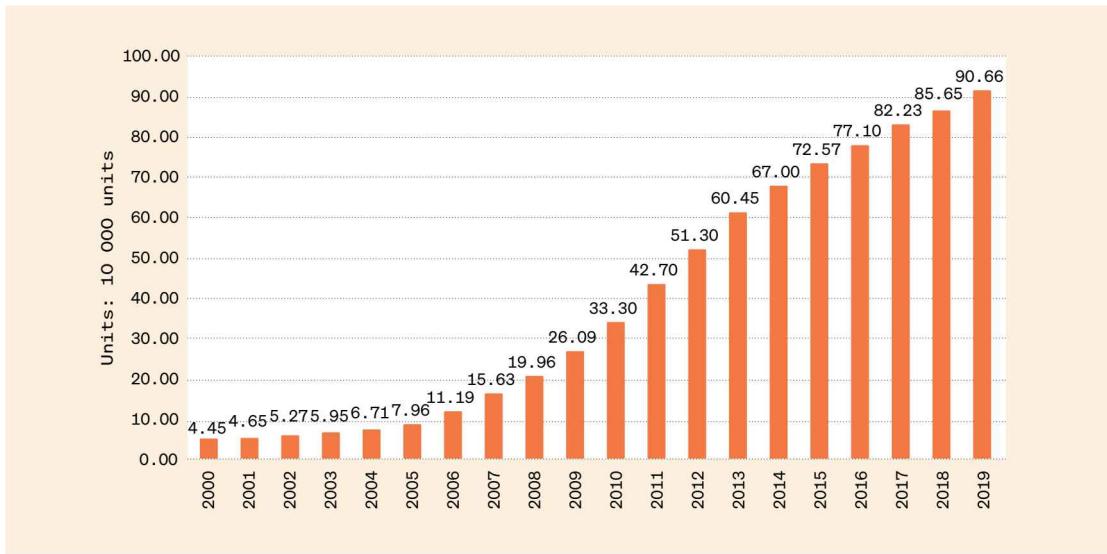


Figure 2
Changes in rice transplanter numbers from 2000 to 2019

SOURCE: Authors' own elaboration. Data sources from **Department of Agricultural Mechanization Management, MARA**. 2000 National Statistical Annual Report on Agricultural Mechanization. July 2001, and for consecutive years to 2019.



Figure 3
Changes in the quantity of maize combine harvesters from 2001 to 2019

SOURCES: Authors' own elaboration. Data sources from **Department of Agricultural Mechanization Management, MARA**. 2001 National Statistical Annual Report on Agricultural Mechanization. July 2002, and for consecutive years to 2019.

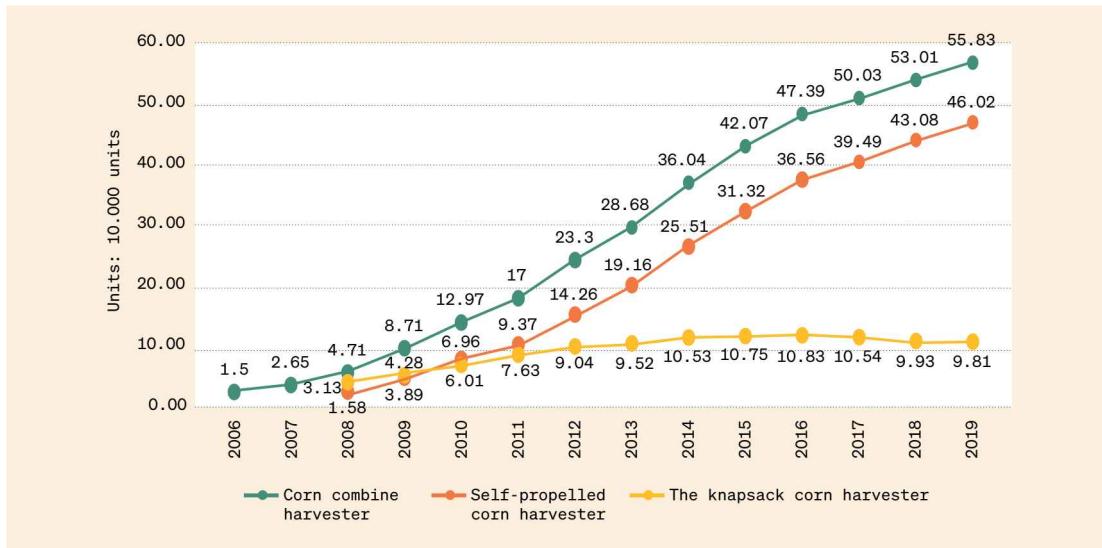


Figure 4

Changes in maize combine harvesters, self-propelled harvesters and knapsack harvesters from 2006 to 2019

SOURCES: Authors' own elaboration. Data sources from **Department of Agricultural Mechanization Management, MARA**. 2006 National Statistical Annual Report on Agricultural Mechanization. July 2007, and for consecutive years to 2019.

and some comprehensive universities in China offer undergraduate programmes in agricultural engineering and agricultural mechanization. The discipline of agricultural engineering has more than 40 master's degree-granting centres and 15 doctor's degree-granting centres, nine universities are authorized to confer doctorate degrees in the first-level discipline of agricultural engineering, and 11 universities are authorized to confer doctorate degrees in the second-level discipline of agricultural mechanization engineering. The total number of undergraduate students, master's candidates, and doctoral candidates majoring in agricultural engineering in China is more than 16 000, 1500, and 300, respectively. Every year, about 4500 agricultural machinery professionals are trained for the industry. From 2016 to 2020, the central government allocated about CNY 980 million (about USD 148 million in 2016) to support eleven task directions:

- information perception of agricultural machinery operations;
- applied basic research on precision control of production and management;
- design and testing of intelligent agricultural machinery and equipment;
- key generic technology development for intelligent operation management;
- intelligent machinery for smart farming;
- high-efficiency, eco-friendly, and multifunctional farmland precision operations;
- intelligent and efficient harvesting technology for staple crops and cash crops;
- intelligent and precision technology and facilities in protected agriculture;

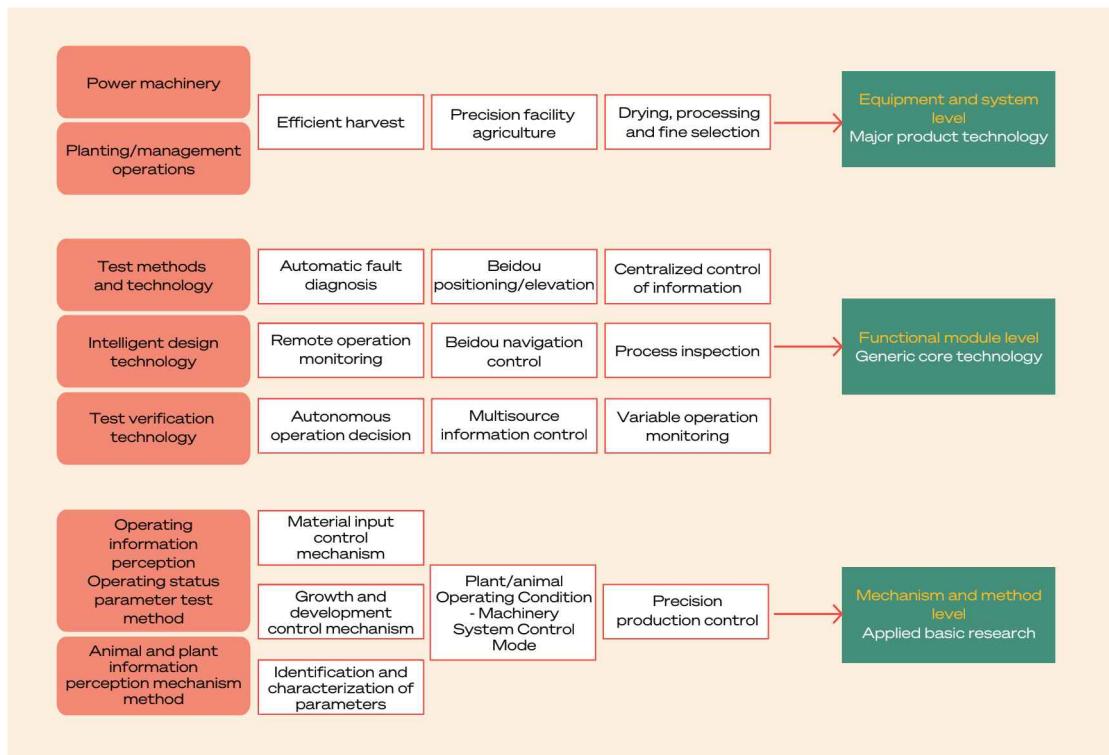


Figure 5

Key demand and innovation chain of intelligent agricultural machinery and equipment industry

SOURCE: Authors' own elaboration.

- technology and R&D of machinery for innovative post-harvest for agricultural products, including intelligent drying, processing, and fine selection;
- intelligent processing of livestock, poultry, and aquatic products in the place of origin; and
- application and demonstration of mechanized operations in hilly/mountainous areas, paddy fields, and other special areas.

R&D for domestic machinery and equipment has been actively promoted in large-size, efficient, compound, green, and intelligent directions. Breakthroughs have been made in some key technologies and equipment, and the challenges of “no usable machinery” have been effectively resolved.

There have been a series of achievements in mechanization in information collection and feedback in areas such as the production process, plant protection, weeding robots, automation, and intelligent technology and systems for the combine harvester, grape/apple fruit-bagging robots, mechanized production for poultry/animals, mechanized collection of animal by-products, processing technology and equipment for classifying agricultural products, fruit and vegetable joint slicing and processing technology, mechanized livestock/aquatic product collection and processing.

Great importance has been attached to strengthening applied basic research and the key demand and innovation chain of the intelligent agricultural machinery equipment industry. It is crucial to break through the bottlenecks in

Table 9**Output of main agricultural machinery products of backbone manufacturers in China in 2020**

Main agricultural machinery products	Units	Production (sets)	Annual increase (%)
Wheeled tractor	Sets	296 670	16.8
Wheeled grain harvester	Sets	23 270	24.2
Maize harvester	Sets	27 890	5.6
Crawler grain harvester	Sets	64 806	13.2
Rice transplanter	Sets	67 722	15.6
Baling machine	Sets	9 792	33.8

SOURCE: **China Machinery Industry Yearbook Editorial Committee, China Agricultural Machinery Industry Association.** 2021. *2020 China Agricultural Machinery Industry Yearbook*. Beijing: China Machine Press.

common core technology, focusing on power machinery, planting/management operations, test detection methods and technology, intelligent design technology, test verification technology, operation information perception, operation state parameter test methods, animal and plant information perception mechanism methods, and other aspects (as shown in Figure 5).

Intelligent agricultural machinery, equipment, and technologies based on Beidou (BeiDou Navigation Satellite System, 2021) and the fifth generation (5G) of mobile technology have been applied in production, such as unmanned tractors, unmanned transplanters, combine harvesters measuring yield/mu (a traditional unit of land area in China, one mu is about one-fifteenth of a hectare), and plant protection drones. Based on this intelligent agricultural machinery and equipment, several experimental unmanned farms began to develop, including unmanned crop fields, unmanned greenhouses, and unmanned fisheries. Using the new generation of information technology, through the intelligent control of facilities, equipment, machinery, etc., unmanned farms can realize all-space, all-day, and whole-process unmanned production operations and achieve a novel agricultural production organization mode. Emergence and development of unmanned farms are derived from the internal requirements of efficient use of resources, the change in labour force structure, and the inevitable trend of information technology development. Unmanned farms are leading the profound transformation of the agricultural development mode in China and will become the mainstream direction of farm development in the future (see Section 9 for more details about future farms in China).

There have been remarkable achievements in China's agricultural machinery industry. At present, this industry has basically formed a complete industrial chain and a relatively complete category of agricultural machinery products. The spare parts supply system can meet the needs of domestic agricultural machinery products. In 2020, there were 1615 agricultural machinery manufacturing enterprises above the designated size, with a business income of CNY 253.34 billion (about USD 38.83 billion), an increase of 7.8 percent over the same period in 2019; the profit realized was CNY 12.35 billion (about USD 1.89 billion), a 23.8 percent annual increase. According to statistical data from the China Association of Agricultural Machinery Manufacturers, in 2020 the output of tractors, harvesters, transplanters, and balers produced by key enterprises in China increased significantly (Table 9).

Table 10

Statistical data on pesticide application and mechanization level from 2010 to 2019

Year	Pesticide application		Mechanization level of plant protection	
	Application (10 000 tonnes)	Increase (%)	Mechanization level (%)	Increment (percentage points)
2010	175.82	-	36.17	-
2011	178.70	1.64	37.24	1.07
2012	180.61	1.07	38.65	1.41
2013	180.19	-0.23	39.16	0.51
2014	180.69	0.28	39.75	0.59
2015	178.30	-1.32	40.32	0.57
2016	174.05	-2.38	41.00	0.68
2017	165.51	-4.91	41.97	0.97
2018	150.36	-9.15	43.38	1.41
2019	139.17	-7.44	44.97	1.59

SOURCES: **Rural Social and Economic Survey Division, National Bureau of Statistics.** 2011 *China Rural Statistical Yearbook*. Beijing: China Statistics Press, October 2011, and for consecutive years to 2019; **Department of Agricultural Mechanization Administration, MARA.** 2010 *National Statistical Annual Report on Agricultural Mechanization*. July 2011, and for consecutive years to 2019.

1.4 WIDE APPLICATIONS OF GREEN AND ENVIRONMENTALLY FRIENDLY MECHANIZATION TECHNOLOGY AND EQUIPMENT PROMOTE THE MODERNIZATION OF GREEN AGRICULTURE

Since 2015, China has vigorously promoted the implementation of the policy of “one control, two reductions, and three basic countermeasures”.

“One control” refers to control over the total quantity of agricultural water and agricultural water environmental pollution. By 2020, the total amount of water used in agriculture was to be controlled at 372 billion cubic metres and the use coefficient was to be increased to 0.55. These problems should be solved mainly through engineering measures and water-saving technical measures to encourage farmers to save water.

“Two reductions” refers to decreases in the quantities of chemical fertilizer and pesticide application. By 2020, the application of chemical fertilizer and pesticide should have achieved zero growth. To solve the problem of chemical fertilizer, it is necessary to improve the accuracy and nutrient use rate of fertilizer by soil testing, formula fertilization, and other technologies. After 2015, the mechanization level of plant protection showed a significantly increasing trend and pesticide use showed a significantly decreasing trend. According to the statistical data for plant protection mechanization levels and pesticide use from 2010 to 2019 (Table 10), linear regression analysis showed that every 1 percentage point increase in plant protection mechanization level could save 45 000 tonnes of pesticide. The mechanization level of plant protection in 2019 was 4.65 percentage points higher than that in 2015, total pesticide reduction was about 210 000 tonnes, and mechanized plant protection contributed to 51 percent of the pesticide reduction. Integration of agricultural mechanization in good agricultural practice and sustainable cropping systems such as integrated pest management, integrated nutrient management and conservation agriculture (FAO, 2022b), made a significant contribution to promoting the transformation of agricultural development, ensuring the quality and safety of agricultural products as well as ecological and environmental security, and promoting sustainable agricultural development.

“Three basic countermeasures” (through resource use, recycling, and non-harmful treatment) are used to solve problems in livestock and poultry pollution treatment, plastic film recycling, straw burning, and other areas. The comprehensive use rate of livestock and poultry manure in China reached 75 percent and the matching rate of facilities and equipment for treatment of manure reached 95 percent on intensive farms (MARA, 2020a). Mechanized production, intelligent equipment, precision control, and other green and eco-friendly mechanization technologies are indispensable for solving these problems.

Within the overarching general objective of conservation agriculture, which is applied as a priority programme to black soils, a number of innovative and leading mechanized technologies have been applied at a faster pace, such as low-fragmentation maize grain harvesting, straw returning, cotton picking and residual film recovery, mechanized transplanting of rice, synchronous side-deep fertilization, and waste disposal for livestock and poultry. In 2019, the conservation agriculture adoption area reached 8.16 million hectares (ha), mechanized no-tillage seeding areas reached 14.6 million ha, precision seeding areas reached 43.1 million ha, mechanized deep fertilization areas reached 35.8 million ha, mechanized straw-returning areas reached 54.3 million ha, and straw picking and baling areas reached 8.9 million ha.

In March 2020, the Ministry of Agriculture and Rural Affairs (MARA) and the Ministry of Finance (MOF) jointly issued the *Action Plan for Conservation Agriculture of Black Soil in Northeast China (2020–2025)* (MARA and MOF, 2020), which deployed the comprehensive promotion and adoption of conservation agriculture in appropriate regions to promote black soil conservation and the sustainable development of agriculture in Northeast China, aiming to adopt and implement conservation agriculture over 140 million mu by 2025, accounting for about 70 percent of the total arable land area in Northeast China. This action plan also aims to establish a relatively complete system of enabling policy, technology, and equipment, and promotion and extension of conservation agriculture. The China Research Centre for Agricultural Mechanization Development at China Agricultural University conducted research on Heilongjiang Beidahuang Jianshan Farm to explore the impact of different tyre technologies on farmland ecology, soil structure, fuel consumption, and emissions, as well as mechanization technology integration and systematic solutions for black soil conservation in Northeast China, from multiple technologies and aspects, to optimize the agricultural ecological environment and ensure food security.

1.5 SUSTAINABLE MECHANIZATION HIRE SERVICE SYSTEMS AND DEVELOPMENT OF FARMERS’ COOPERATIVES INCREASE AGRICULTURAL PRODUCTIVITY AND FARMERS’ INCOME AND LIVELIHOODS

In recent years, private sector-led agricultural mechanization cooperation specialized in hire service and other mechanization service organizations have played an important role in greening agricultural modernization, promoting sustainable agricultural practices, demonstrating eco-friendly and climate-smart agricultural production systems, and strengthening agrifood value chains. Through good public-private partnerships (PPP), agricultural mechanization service providers/organizations also played crucial roles in supporting agricultural production in important farming periods; guaranteeing the food supply in rural, urban, and peri-urban areas; promoting the mechanized and intelligent digital development of food systems; and strongly supporting rural employment in agriculture and livelihoods.

EXPLANATION OF MAIN TERMS IN THIS REPORT

- **Land Trusteeship Service:** the Land Trusteeship Service is a form of land circulation. It refers to the practice through which some farmers who are unwilling or unable to cultivate land entrust their land to large-scale farmers or cooperatives and let them cultivate and manage their land on their behalf. Through large-scale land trusteeship services, intensive land management has been realized under China's household contract management system, mechanized production and modernized management promoted, production efficiency increased, and farmers' income raised. Land trust is an essential socialized service in China. Farmers can entrust cooperatives with a certain agricultural production link, or with all production links. Trusteeship organizations or cooperatives drive various business entities to carry out large-scale modern agricultural production with socialized services (including mechanization hire services), and realize specialized, intensive and standardized management.
- **Agricultural households with machinery:** households that own agricultural machinery (more than 2 kW) for commercial farm operations, or carry out agricultural machinery operations for their own use or for others, without strict regulations or management methods (MARA, 2019).
- **Agricultural mechanization cooperatives specialized in hire services:** farmers' cooperatives specialized in agricultural mechanization hire services, which are established in accordance with the *Law on Specialized Farmers' Cooperatives of the People's Republic of China, Regulations on Registration and Administration of Specialized Farmers' Cooperatives, Standard Charter on Specialized Farmers' Cooperatives* and the other relevant laws and regulations (MARA, 2019).
- **Agricultural mechanization hire service organizations:** entities engaged in various agricultural machinery operation services. These entities have charters, appropriate scales of operation and relatively stable sites. Agricultural mechanization hire service organizations include agricultural mechanization service stations (teams), agricultural machinery cooperatives, small- and medium-sized enterprises (SMEs) providing agricultural machinery operation services that are sponsored by the state, collectives, and individuals. Among them, there are special statistics on the original value of agricultural machinery of more than CNY 500 000 (including CNY 500 000) (MARA, 2019).
- **Mechanization hire services:** all kinds of agricultural equipment and machinery operation services along the agrifood value chain provided by specialized farmers/ households or hire service organizations (i.e. cooperatives or SMEs), and other agricultural providers of services, including mechanized land preparation, mechanized seeding/transplanting, mechanized harvesting, drainage and irrigation, plant protection, as well as related agricultural machinery repair and maintenance, supply, intermediary, lease, and other paid services.

SOURCES: Authors' own elaboration; MARA. 2019. *China's Agricultural Mechanization Management Statistical Survey System*. Beijing, China. www.moa.gov.cn/govpublic/NYJXHGLS/201902/P020190220505651335298.doc

MARA. 2021. *2020 National Statistical Annual Report on Agricultural Mechanization*. Beijing, China.

The socialized agricultural mechanization hire service providers usually adopt order services, land trusteeships, land transfers, and other mechanisms that are involved in large-scale operations and have promoted the agricultural production development of small farmers. In terms of service content, innovative models of mechanization hire services are developing continuously such as “*integration of machinery and agriculture* (hire service provider, operator, and farmer)” and “*whole-process mechanization + integrated agricultural service centre*”, and more and more business models have been adopted to achieve a win-win situation for farmers and service providers (e.g. cooperatives). The agricultural mechanization hire service organizations provide one-stop comprehensive agricultural services along the agrifood value chain for farmers operating at different scales, making important contributions to promoting sustainable, advanced, and green agricultural technologies. Major agricultural mechanization services cover crop production, field management (e.g. fertilization and pest control), harvesting, and post-harvest processing, as well as machinery repair and maintenance. In addition, these agricultural machinery service organizations provide comprehensive agricultural social services, such as procurement of agricultural inputs, technology demonstrations, and consulting and training, as well as enterprise and product sales. With the support of land transfer and circulation policies in China, farmers can buy shares in cooperatives through their land and they can use their land/capital to buy shares and obtain dividends.

Land trusteeship provides innovative and flexible hire services, including the following:

- *Full trusteeship*: for large-scale farmers or small-scale farmers based on the village as a unit. This can both facilitate centralized management and combine the scattered small-scale farmlands into large-scale lands so that large-scale agricultural machinery can perform better.
- *Partial trusteeship*: according to customer demand, this will provide selected mechanization services for production, management, harvesting, and other links along the agrifood value chain.

At present, the agricultural mechanization hire service in China is developing steadily, led by 74 000 agricultural mechanization cooperatives and nearly 200 000 agricultural mechanization hire service organizations, together with 4.24 million specialized mechanization service providers as the backbone, as well as 40 million agricultural households with machinery providing the basis for farming activities. As shown in Table 11 (data for 2008–2019), the number of agricultural mechanization hire service organizations with an original value of CNY 200 000 to CNY 500 000 showed a decreasing trend, whereas the number of agricultural mechanization hire service organizations with an original value of more than CNY 500 000 showed an increasing trend. The number of agricultural mechanization cooperatives with an original value of CNY 1 million or more has increased rapidly and reached 28 082, accounting for 38 percent of the total. The total number of agricultural households with machinery showed a decreasing trend annually, whereas the number of agricultural households with machinery with an original value of CNY 200 000 to CNY 500 000 and an original value of CNY 500 000 or more was still increasing. The scales of agricultural mechanization hire service organizations (including agricultural mechanization cooperatives) and mechanized family farms have been expanding continuously, showing the developing trend of modern agriculture and driving the development of small-scale farmers. The total income of agricultural mechanization hire services has reached CNY 473 billion (about USD 68.58 billion).

Table 11

Changes in agricultural mechanization hire service organizations and agricultural households with machinery in China from 2008 to 2019

Year	Agricultural mechanization hire service organizations (units)				Agricultural households with machinery (ten thousand households)			
	Total amount	Original value of agricultural machinery (CNY 200 000 to 500 000)	Original value of agricultural machinery (CNY 500 000 or more)	Agricultural mechanization cooperatives specialized in hire service	Total amount	Original value of agricultural machinery (CNY 200 000 to 500 000)	Original value of agricultural machinery (CNY 500 000 and above)	
				Number of cooperatives				
2008	165 636	42 155	8 704	8 622	–	3 833	34.3	3.2
2009	175 329	45 671	12 242	14 902	–	3 949	35.5	3.5
2010	171 465	45 873	15 843	21 760	–	4 058	38.7	4.1
2011	170 572	44 282	19 635	27 848	–	4 111	39.5	4.9
2012	167 038	48 322	24 240	34 429	–	4 192	40.9	5.3
2013	168 574	53 098	29 313	42 244	–	4 238	46.4	5.8
2014	175 124	56 388	34 584	49 435	–	4 291	50.1	7.5
2015	182 453	58 043	39 173	56 525	–	4 336	52.7	7.9
2016	187 301	60 453	43 229	63 184	–	4 229	53.0	8.3
2017	187 358	58 784	46 720	68 007	–	4 185	53.5	8.5
2018	191 526	–	53 814	72 640	26 327	4 080	67.0	–
2019	192 173	–	56 661	74 438	28 082	4 074	67.9	–

SOURCES: Department of Agricultural Mechanization Administration, MARA. 2008 National Statistical Annual Report on Agricultural Mechanization. July 2009, and for consecutive years to 2019.

Note: Starting from 2018, the National Statistical Annual Report on Agricultural Mechanization would no longer count the service organizations which have an original value of agricultural machinery from CNY 200 000 to 500 000, or the agricultural households with machinery which have an original value of agricultural machinery of CNY 500 000 and above. Statistics on specialized agricultural machinery cooperatives with an original value of 1 million yuan or more were added in 2018.

The *Guiding Opinions of the State Council on Accelerating the Promotion of Agricultural Mechanization and the Transformation and Upgrading of the Agricultural Machinery and Equipment Industry* (Guofa [2018] No. 42) clearly requires the construction of several “whole-process mechanization + integrated agricultural service centres”. In 2019 and 2020, MARA reported 110 case studies of “whole-process mechanization + integrated agriculture service centres”. These successful cases featured innovative service and business models, optimized service mechanisms, minimized shortcomings in service, and enhanced service capacity. Moreover, a main trend is to optimize mechanization services along the agrifood value chain, from production to harvesting, and post-harvest drying and processing, and expand one-stop services to unified agricultural input purchasing, technology demonstration, consultation and training, marketing and sales, and other such areas. The “whole-process mechanization + integrated agriculture service centres” significantly contribute to cost saving and efficiency improvement, along with the extension and improvement of agricultural science and technology. This has explored effective ways to solve the challenges in agricultural production for farmers and promote the development of moderate-scale operations in agriculture.

TRAINING FOR GRASSROOTS AGRICULTURAL MACHINERY PERSONNEL AND CHAIRPERSONS OF AGRICULTURAL MECHANIZATION COOPERATIVES

In June 2018, the China Research Centre for Agricultural Mechanization Development at China Agricultural University held a training course for grassroots agricultural machinery personnel and chairpersons of agricultural mechanization cooperatives in Shanghai. Many young and women chairpersons attended the training course. The training content included:

- transformation and upgrading of whole-process agricultural mechanization and agricultural mechanization hire services;
- progress in rice mechanization technology;
- mechanized drying technology and equipment for grain and cash crops;
- rice cultivation and benefits; and
- enhancing the added value of agricultural products: marketing innovation and novel ideas.



In June 2018, the China Research Centre for Agricultural Mechanization Development at China Agricultural University held a training course for grassroots agricultural machinery personnel and chairpersons of agricultural mechanization cooperatives in Shanghai.

SOURCE: Authors' own elaboration.

The agricultural machinery service organization focuses on serving smallholders and explores flexible and diversified service modes according to different customer groups. Agricultural mechanization services not only increase employment opportunities but also contribute to poverty reduction. In some poor areas, agricultural mechanization service organizations have lowered operation fees and provided training in agricultural skills for smallholders.

The good PPP models and related synergistic effects successfully promote the sustainable development of agricultural mechanization hire services. For example, to promote conservation agriculture in Heilongjiang, Jilin, Liaoning and other provinces, agricultural machinery cooperatives actively collaborated with agricultural extension agencies and agricultural mechanization production enterprises in testing and promoting the new no-tillage seeder suitable for smallholders. Cooperation with research institutions further promoted the

BEIJING XINGNONG TIANLI AGRICULTURAL MECHANIZATION SPECIALIZED SERVICE COOPERATIVE, BEIJING

Chen Guolong, the 33-year-old general manager of Beijing Xingnong Tianli Agricultural Mechanization Specialized Service Cooperative, along with his father Chen Ling (president of the cooperative, junior college graduate, 60 years old), has been engaged in work on agricultural machinery cooperatives since he graduated from university. He belongs to the second generation of machinery operators.

- After land transfer and circulation, large-scale agricultural production was implemented, which greatly improves the operating efficiency of large-scale agricultural machinery, decreases costs and increases yield.
- In order to optimize productivity, the cooperative organizes for farmers who transfer their land to conduct scientific agricultural production training. The cooperative provides farmers with insurance, benefits and paid leave, thus allowing them to become specialized farmers in the new era.
- The cooperative is creating an ecological agricultural and agritourism industrial park.
- The cooperative often receives study tours for trainers from agricultural machinery training courses in developing countries, organized by the State Administration of Foreign Affairs.



Chen Guolong (left), general manager of the Beijing Xingnong Tianli Agricultural Mechanization Specialized Service Cooperative, and activities of the cooperative.

SOURCE: Authors' own elaboration. Pictures provided by Beijing Xingnong Tianli Agricultural Mechanization Specialized Service Cooperative.

integration of agricultural mechanization and agronomy, developed agricultural mechanization solutions for sustainable plant production and protection, and adopted digital intelligent systems such as plant protection drones and intelligent navigation equipment to provide advanced, green, and intelligent agricultural mechanization services for smallholders.

At present, China's agricultural production has entered a new stage led by mechanization. China will continue strengthening the guidance and support for new business forms, new business models, and new business entities of socialized agricultural mechanization hire services. In the “whole-process mechanization + integrated agriculture service centres” model, China will continue accelerating the adaptation of agricultural machinery service models to appropriate-scale agricultural operations; and promote the comprehensive, high-quality, and efficient development of agricultural mechanization in China's diversified agricultural ecosystems (e.g. paddy field or dryland, plains or mountainous areas). Additionally, China will continue enhancing the connection

MENGBIN GELAN FARMERS' COOPERATIVE SPECIALIZED IN PIG PRODUCTION AND MARKETING IN LANCANG COUNTY, YUNNAN PROVINCE

Zhang Xiaopeng is the 33-year-old chairperson of Mengbin Gelan Farmers' Cooperative Specialized in Pig Production and Marketing, Lancang County, Yunnan Province.

Zhang has been engaged in potato farming in Inner Mongolia since he graduated from university. After graduating, he and his wife, Wu Tingting (32 years old, a high school graduate), returned to his wife's hometown in Lancang County to inherit his wife's parents' business and develop the family farming industry of pig and crop production. Wu also belongs to the second generation of farming.

This agricultural enterprise was established on 29 September 2010, covering an area of 1600 mu (106.7 ha). It integrates crop and animal production, related industrial research, technology improvement, technical training, livestock intensification, and primary processing and sales.

Potato planting mainly relies on human labour in Lancang County. Potato planting has nine operational procedures: ditching, planting, fertilization, ridging, soil covering, pesticide application, film covering, film pressing, and covering soil with film. It takes eight people one day to complete the nine procedures for planting an area of 1 mu.

If being used on flat land, a mechanized planter can complete all nine procedures at a time and four people can complete a planting area of 15–20 mu/day. If using the mechanized planter on sloping land, four people can complete a planting area of at least 10 mu/day.

The benefits of mechanization have encouraged the participation of surrounding farmers to use agricultural machinery.



Zhang Xiaopeng and Wu Tingting (left), chairpersons of the Mengbin Gelan Farmers' Cooperative Specialized in Pig Production and Marketing in Lancang County, Yunnan Province.

SOURCE: Authors' own elaboration.

between smallholders and modern agricultural development, so contributing to rural revitalization.

The average age of the chairpersons and members of agricultural mechanization cooperatives in China is still over 46 and some chairpersons are even older than 50. However, with the expansion of agricultural operation scale, the strengthening of government support and enabling policies, the continuous development of intelligent agricultural machinery and equipment, and the continuous improvement of agricultural production conditions, more and more young people, especially some university graduates, have gradually entered the agricultural sector as a career path. In October 2018, the China Association of

JIANGSU RUNGUO AGRICULTURAL DEVELOPMENT CO., LTD., JIANGSU PROVINCE

Wei Qiao, chairperson (female, master's degree, graduate of the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences), and Sun Zhenzhong, general manager (doctoral degree, graduate of the School of Urban and Environmental Sciences, Peking University, previously a post-doctoral researcher), Jiangsu Runguo Agricultural Development Co., Ltd. (hereafter Runguo Agriculture). The couple left academia in Beijing and established a new farmer team for Runguo and led the innovations in mechanization and digital agriculture.

This agricultural enterprise was established in 2009, covering 22 500 mu of leased land. It mainly conducts whole-process mechanized production of rice and wheat, agricultural mechanization hire services, digital agriculture, post-harvest processing, and agricultural technical services. It also serves the surrounding 25 000 mu of farmland.

Runguo Agriculture has created a “company + cooperative + farmer agricultural production service organization” model. This enterprise emphasizes agricultural science and technology along the entire industrial chain and agrifood value chain of rice and wheat production, integrating land preparation, planting, management, harvesting, drying, storage, processing, and sales. The enterprise has formed a modern agricultural business model that is profitable, sustainable, and reproducible, thus achieving a win-win situation.

Runguo Agriculture adheres to the development direction of digital agriculture. In 2020, Runguo Agriculture cooperated with Yangzhou University, Fengjiang Intelligence, and DJI Agriculture to build the nation's first new model of a 5000 mu unmanned farm with an agricultural mechanization demonstration that integrates space, ground and air. It takes the lead in seeking solutions for the implementation of smart farms and exploring the novel models of high-quality development of future agriculture.



© Jiangsu Runguo Co., Ltd./Zhenzhong Sun

Jiangsu Runguo Agricultural Development Co., Ltd.

Wei Qiao, chairperson (left), and Sun Zhenzhong, general manager (right).

SOURCE: Authors' own elaboration. Pictures provided by Zhenzhong Sun, Jiangsu Runguo Agricultural Development Co., Ltd.

HONGMEI FAMILY FARM IN SANTAI COUNTY, SICHUAN PROVINCE

Lin Hongmei (female) is the 49-year-old owner of Hongmei Family Farm in Santai County, Sichuan Province. Lin graduated from high school and is a local model worker. She not only conducts grain planting on 1000 mu of circulated land but also provides agricultural mechanization operation services for more than 600 surrounding households. In addition, she manages the Hongyun Agricultural Mechanization Specialized Cooperative with her husband.

Hongmei Family Farm provides integrated agricultural mechanization hire services for production and management. These services include mechanized seeding, plant protection, harvesting, primary processing of agricultural products, and consulting services for information, technology, and maintenance. With the development objectives of using the best cultivated varieties and advanced management and driving agricultural development in the area, the experiences of Hongmei Family Farm include:

- communicating with each production team, identifying the operating area and requirements, issuing operating tasks to the operators, and scheduling machinery operations;
 - organizing and carrying out scientific experimental tasks (in collaboration with research institutes); and
 - learning advanced planting techniques, guiding members in scientific planting and field management, and standardizing the operation of machinery and equipment.
- Hongmei Family Farm helps poor households in the village to escape from poverty and improve their livelihoods. In addition to providing low-cost agricultural inputs (seed, fertilizer and pesticide) to villagers, and obligatorily providing technical guidance and purchasing and transportation services, the farm provides at least 16 relatively fixed jobs every year.



Lin Hongmei (above), farm owner of Hongmei Family Farm in Santai County, Sichuan Province.

SOURCE: Authors' own elaboration.

MINDA SPECIALIZED PLANTING COOPERATIVE IN JIALING DISTRICT, NANCHONG CITY, SICHUAN PROVINCE

Chen Yurong (female) is the 52-year-old chairperson of Minda Specialized Planting Cooperative in Jialing District, Nanchong City, Sichuan Province. Chen had set up a company in the city. In 2015, she returned to her hometown to start her own business. She developed a mixed farming industry with the mode of whole-process mechanization of plant and livestock production, and she provides mechanization services for production and harvesting. The business makes a good profit. Activities of the cooperative follow:

- adopting the whole-industry chain model of “centralized land management and production + whole-process mechanization of field production + post-harvest treatment → product added value → brand building → e-commerce (online and offline sales network) → mechanization and information integration” to promote industrial development;
- circulation of 485.05 mu of land and providing agricultural mechanized services for production and harvesting;
- the business scope of the cooperative involves production and sales of crops, vegetables, fruit trees, flowers, and seedlings; aquaculture and sales; processing and sales of agricultural and sideline products; providing members with technical information and services related to agricultural production; and
- cooperating with the local Agricultural and Rural Bureau to organize technical training twice a year.



Chen Yurong (left), chairperson, Minda Specialized Planting Cooperative in Jialing District, Nanchong City, Sichuan Province.

SOURCE: Authors' own elaboration.

Agricultural Mechanization established the Working Committee of Cooperative Chairpersons with the participation of more than 70 cooperative chairpersons, who are all college graduates. The “second generation of machinery operators” (whose parents are engaged in agricultural machinery operations) or “third generation of machinery operators” (whose grandparents are engaged in agricultural machinery operations) inherit the family farming/industry and become engaged in agricultural mechanization cooperative work. It is clear that the chairpersons of agricultural mechanization cooperatives in China and the main personnel engaged in agricultural mechanization hire services are transforming in a younger and high-competency direction, and women and youth are playing more and more important roles in agricultural production.

AXIANG AGRICULTURAL MECHANIZATION SPECIALIZED SERVICE COOPERATIVE IN LONGSHAN COUNTY, HUNAN PROVINCE

Yang Meixiang (female) is the 50-year-old chairperson of Axiang Agricultural Mechanization Specialized Service Cooperative in Longshan County, Xiangxi Prefecture, Hunan Province. Yang graduated from high school and is a model worker in Xiangxi. She is a leader for her husband, son, daughter-in-law, daughter, and son-in-law in work in the agricultural mechanization cooperative. Yang leads the development of the agricultural industry and helps poor households in the surrounding areas escape from poverty.

- Owning a land area of 3000 mu, the cooperative realizes the whole-process mechanization of the cultivation-planting-harvesting-drying process of rice and rapeseed production. The machinery and equipment include large rotary tillers, walk-behind tillers, dryers, rice and rapeseed harvesters, high-speed rice transplanters, hand-supported rice transplanters, rapeseed direct-seeding machines, electric high-pressure plant protection machines, and irrigation equipment, totalling an installed capacity of 150 kW.
- The cooperative adopts a full industrial chain model of “centralized land management and planting + whole-process mechanization of field production + post-harvest treatment → enhancement of product added value → brand building → offline sales → promotion of industrial development”.
- The cooperative has helped 50 poor households in the village through a set of measures including paying land circulation and transfer fees, employing local labour, providing technical demonstrations, absorbing poor households into the cooperative, and providing free agricultural machinery operations and unified sales. The cooperative leads the development of the local agricultural industry and lifts neighbouring poor households out of poverty.



Yang Meixiang (left), chairperson, Axiang Agricultural Mechanization Specialized Service Cooperative in Longshan County, Xiangxi Prefecture, Hunan Province.

SOURCE: Authors' own elaboration.

1.6 WELL-ORGANIZED AGRICULTURAL MACHINERY MANAGEMENT, EXTENSION SERVICE SYSTEMS, AND INFORMATION TECHNOLOGY IMPROVE THE CAPACITY OF PUBLIC SERVICE

The agricultural machinery management and extension system has been improved at national, provincial and city/county levels. The platform for the pilot system for national agricultural machinery purchase subsidies has been established. It will allow farmers to apply for agricultural machinery purchase or operation subsidies using mobile phones, apply for agricultural machinery operation subsidies, and handle the relevant financial credit procedures for agricultural machinery purchases. In addition, the platform also provides the “one-machine-one-code” storage system for farm machinery products and financial subsidies for real-time monitoring of agricultural machinery operations. Many regions (provinces) have set up information platforms for agricultural mechanization management, thus providing strong support for machinery industry management, scientific decision-making and information monitoring. The optimized agricultural machinery test and appraisal system lays the foundation for agricultural machinery products to meet the relevant technical standards and ecological requirements. The online system for handling relevant procedures effectively improves the efficiency of policy implementation and online services, including agricultural machinery purchasing subsidies and testing and appraisal of agricultural machinery.

1.7 SUSTAINABLE AGRICULTURAL MECHANIZATION IN MOUNTAINOUS AND HILLY AREAS PROVIDES SUPPORT FOR THE PROSPERITY OF THE AGRICULTURAL INDUSTRY AND POVERTY REDUCTION

The hilly and mountainous areas are the important production bases for fruit, vegetable, tea, grain and oil crops in China. China's hilly and mountainous counties cover about 46.686 million ha of arable land, accounting for 34.62 percent of the country's total arable land. The sown area is 56.731 million ha, accounting for 34.20 percent of the country's total sown area. Crop production from these hilly and mountainous areas accounted for the following percentage of production for the total national area: tea plantation 93.39 percent, orchard 62.28 percent, potato 78.58 percent, sugarcane 62.78 percent, rapeseed 57.53 percent, rice 39.60 percent, and vegetable 37.29 percent.

Over 1400 counties in China are in the hilly and mountainous areas. In 2018, the permanent rural population of hilly and mountainous counties in China was 298.1 million, accounting for 52.85 percent of the rural population. The comprehensive mechanization level of production and harvesting is 46.87 percent in 1429 hilly and mountainous counties, which is 21.92 percentage points lower than the national average and 33.87 percentage points lower than that of the non-hilly and non-mountainous counties. If hilly and mountainous counties cannot achieve agricultural mechanization, it will be difficult to realize agricultural modernization nationally.

The Chinese Government attaches great importance to the development of agricultural mechanization in hilly and mountainous areas and requires the achievements made in poverty alleviation to be effectively linked with rural revitalization. To meet the urgent needs in poor hilly and mountainous areas, related machinery and equipment subsidies have been included in the scope of national subsidies for the development of special agricultural product industries, such as tea, edible fungi, fruit, forestry, and other special agricultural product industries. The subsidy standard has been increased from 30 percent (the common subsidy standard is 30 percent) to 35 percent to support hilly and

WHAT HAPPENS IN A “SUITABLE FOR MECHANIZATION” TRANSFORMATION IN HILLY AND MOUNTAINOUS AREAS?

China has 1429 counties of hills and mountains; most of the farmland is hilly and mountainous and not suitable for mechanized operations. The *Guiding Opinions on Accelerating the Promotion of Agricultural Mechanization and the Transformation and Upgrading of the Agricultural Machinery and Equipment Industry* issued by Chinese State Council (2018), made the proposal to “improve the basic conditions of agricultural machinery operations”, and set out requirements for the field track and field length, width and flatness to be “suitable for mechanization”.

The aim was to coordinate relevant funds from central and local governments and private capital to actively develop high-standard farmland, promote the consolidation of small plots of farmland to make larger plots, to transform plots from short to long, extend agricultural machinery operation lines, turn steep slopes into gentle slopes, and remove curves so as to realize the continuity and interconnection of farmland, effectively improve the passage and operation conditions of agricultural machinery, and improve the adaptability of agricultural machinery.

It further aimed to focus on supporting the mechanization of farmland in hilly and mountainous areas, expand the space for large- and medium-sized agricultural machines to be used, and speed up efforts to improve the weak basic conditions for agricultural mechanization in hilly and mountainous areas.

SOURCE: Authors' own elaboration; **Chinese State Council**. 2018. *Guiding Opinions of the State Council on Accelerating Agricultural Mechanization and the Transformation and Upgrading of Agricultural Machinery and Equipment Industry* (Guofa [2018] No. 42). Cited 30 April 2021. http://www.gov.cn/zhengce/content/2018-12/29/content_5353308.htm

mountainous areas and other poor area industries to optimize mechanization in the development of special agricultural product industries.

Additionally, it is vital to optimize agricultural machinery operating conditions in hilly and mountainous areas. The Ministry of Agriculture and Rural Affairs selected and reported 11 representative cases of “suitable for mechanization” farmland transformation. It is critical to promote the two-way strategy of “farmland fit for machinery” and “machinery fit for farmland”, strengthen the legal system, and provide construction and policy support. Some hilly and mountainous provinces have carried out suitable-for-mechanization farmland transformation to optimize the suitable conditions for agricultural machinery operation through the integration of scattered irregularly shaped small-scale plots, flattening slopes, and zonal distribution of plots. For example, the mountainous area of Chongqing has been implementing suitable-for-mechanization farmland transformation of more than 800 000 mu, including 350 000 mu for grain production (Figure 6). Shanxi Province has been implementing farmland transformation of 20 000 mu. Sichuan Province has been implementing farmland transformation of 60 000 mu (Figure 7). In 2020, Sichuan Province invested CNY 110 million in carrying out suitable-for-mechanization transformation and in 2021 CNY 150 million was invested to develop agricultural mechanization, of which about 75 percent was used for suitable-for-mechanization transformation.

The China Research Centre for Agricultural Mechanization Development at China Agricultural University, relying on the Thirteenth Five-Year Plan national



Figure 6

Suitable-for-mechanization transformation of circulated land, before (left) and after (right), Zhanghong ecological agriculture co., Ltd., Tongnan, Chongqing

SOURCE: Authors' own elaboration. Pictures provided by He Zhong, Agricultural Machinery Technology Extension Station, Chongqing Tongnan Agricultural Science and Technology Extension Center.



Figure 7

Suitable-for-mechanization transformation of circulated land, before (left) and after (right), Hongmei family farm, Santai, Sichuan

SOURCE: Authors' own elaboration.

key research and development project *Integration and Demonstration of Key Technologies of Moderate-Scale Production of Staple Crops in Hilly and Mountainous Areas*, focuses on the main challenges of developing mechanization in hilly and mountainous areas, that is those lacking suitable machinery and equipment and being a poor fit in the moderate-scale production of wheat and maize (Figure 8). Through experiments and research on mechanized land preparation, seeding, plant protection and harvesting in the wheat-maize system, and selection and modification of efficient operational equipment, the centre demonstrated and established moderate-scale mechanization of the agricultural production system, significantly contributed to the transformation and upgrading of the production of wheat and maize, and provided scientific theory and technical equipment support for the scaling up, sustainable intensification, and standardization of mechanized crop production (Figure 9). Additionally, key equipment and information-based management technologies were developed and integrated for appropriate large-scale agricultural production. Demonstrations of complete sets of equipment were conducted for the mechanized production

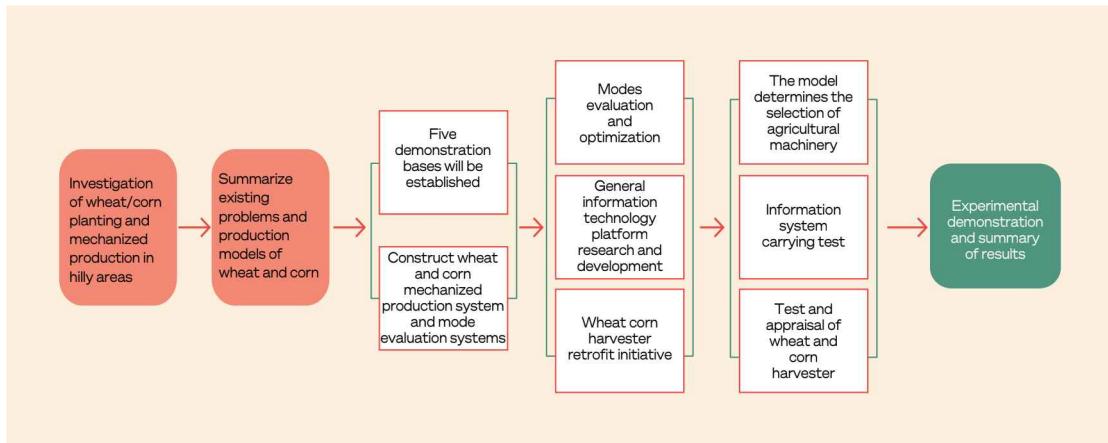


Figure 8

Research flow of the project “integration and demonstration of key mechanization technology in the whole process of moderate-scale production of staple crops in hilly and mountainous areas”, China Research Centre for Agricultural Mechanization Development, China Agricultural University

SOURCE: Authors' own elaboration.

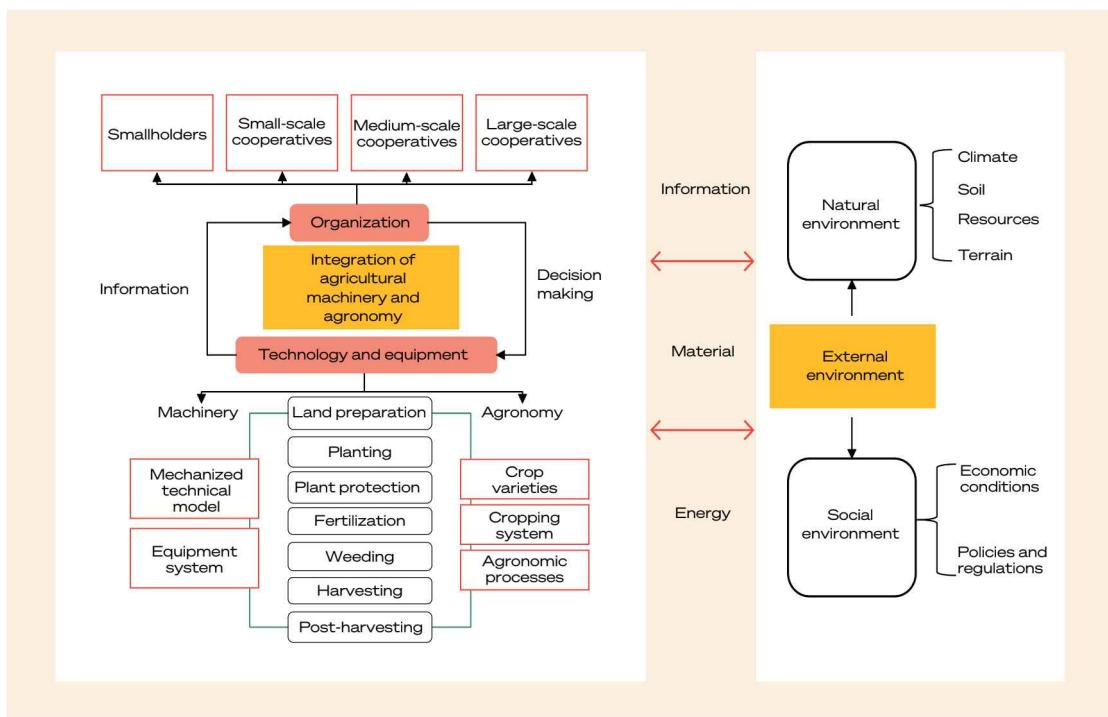


Figure 9

Constructing moderate-scale and whole-process mechanized production system of wheat and maize in hilly areas

SOURCE: Authors' own elaboration.

system of wheat and maize. The research results have been promoted and applied in some hilly and mountainous provinces.

1.8 SUMMARY

Overall, China's agricultural production has entered a new stage led by mechanization. From 2016 to 2020 was the stage of full-course, high-quality, and efficient transformation and upgrading of agricultural mechanization to fully support and serve agricultural production. The total power of agricultural machinery in China reached 1.03 billion kilowatts (1030 GW), with a total of 200 million sets of machinery, with an original value of nearly one trillion CNY. The foundation for mechanization has become more solid to support the development of various sectors of the agricultural industry, thus significantly contributing to China's total grain yield of 650 million tonnes annually. The application of mechanization technology such as saving seed, water, fertilizer, and pesticides, especially the wide application of precision fertilization and efficient mechanized plant protection technology, has realized the goal of zero growth of the use of chemical fertilizer and pesticides. Green and environmentally friendly mechanization technologies compatible with the concept of conservation agriculture have been vigorously promoted, such as straw returning and mulching, residual film recovery, and resource use of manure. The comprehensive use rate of livestock and poultry manure has reached 75 percent nationwide and the matching rate of equipment for non-harmful treatment of manure on large-scale farms has reached 95 percent. China has 74 000 agricultural mechanization cooperatives and nearly 200 000 agricultural machinery service organizations, more than 4.2 million agricultural households specialized in mechanization hire service, and more than 40 million agricultural households with machinery. Annual revenue from agricultural mechanization services exceeded CNY 470 billion, thus supporting the employment and livelihood of nearly 150 million rural dwellers.

The experiences in agriculture and agricultural mechanization in China over the past 40 years since the reform and opening up, has proved that the reform of the agricultural production mode triggered by the extensive application of machinery in production has greatly improved agricultural productivity and effectively guaranteed China's agricultural development and food security. China's population has grown from 960 million in 1978 to 1.4 billion; without the development of agricultural mechanization, it would be difficult to feed so many people. At the same time, the proportion of the labour force engaged in agriculture has decreased (from 90 percent to 25 percent) and more people are engaged in other decent jobs. This has promoted the division of labour in different production sectors, promoted the development of industry and tertiary industry, promoted national economic prosperity, and made significant contributions to world food security and sustainable development.



Chapter 2

Main practices and experiences

This section describes the main practices and experiences of China's sustainable agricultural mechanization development. The policy, institutional and technical support for agricultural mechanization includes the Chinese Government attaching great importance to the development of agricultural mechanization; a complete system of laws, regulations, and policies for agricultural mechanization; the central government and provincial governments setting up special funds to support agricultural machinery purchase subsidies and operation subsidies; the implementation of the construction of high-standard farmland and the suitable-for-mechanization transformation of farmland in hilly and mountainous areas; promoting agricultural machinery and equipment technology innovation, extension and application; capacity development for agricultural mechanization hire service providers and organizations; and follow-up on investigation and supervision of agricultural machinery and equipment. Furthermore, this section discusses the major contribution of agricultural mechanization to restoring agricultural production, ensuring food security and promoting employment during and after the COVID-19 pandemic.

2.1 GREAT SUPPORT PROVIDED BY THE CHINESE GOVERNMENT

Chinese President Xi Jinping stressed the need to vigorously promote agricultural mechanization, digitalization and information technology, to accelerate agricultural modernization with science and technology, and to strengthen the construction of modern agricultural infrastructure such as agricultural mechanization. After the reform of state institutions in 2018, the State Council and the agricultural and rural departments of people's governments at all levels set up agricultural mechanization management agencies. The Ministry of Agriculture and Rural Affairs (MARA) and the Ministry of Industry and Information

Technology (MIIT) have taken the lead and established a national mechanism consisting of 17 departments for coordinating and promoting the development of agricultural mechanization in China.

Article 18 of Chapter II of the *Law on Promotion of Rural Revitalization of the People's Republic of China*, promulgated in 2021 (hereafter “the Law on Rural Revitalization”) explicitly states: the state encourages research, development, extension, and application of agricultural machinery; promotes mechanization in the whole-process production of staple crops; and improves the machine and equipment level of protected agriculture, forestry and grassland, animal husbandry, fishery, and primary processing of agricultural products. The aim is to promote the integration of agricultural machinery and agronomy, the integration of mechanization and information technology, the adaptation of mechanized production to farmland construction, and the adoption of mechanization hire service models to moderate-scale agricultural operations (Xinhua News Agency, 2021b).

Every Five-Year Plan for national economic and social development in China contains an elaboration on the development of agricultural mechanization. The *Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-Term Goals for 2035* (Xinhua News Agency, 2021a) clearly emphasized the need “to implement projects on black soil conservation and to strengthen black soil conservation and fertility recovery in Northeast China”; “to strengthen the R&D and application of large- and medium-sized, intelligent, compound agricultural machinery”; and “to increase the comprehensive mechanization rate of crop production (e.g. land preparation, seeding/planting, crop husbandry and harvesting) to 75 percent”. In addition, in the *Special Column 10 Modern Agricultural and Rural Construction Project* (Chinese State Council, 2021), two related special projects have been set up. The main content of Special Project “01 well-facilitated farmland” includes establishing 275 million mu of well-facilitated farmland, among which water-saving irrigation areas cover 60 million mu, and implementing conservation agriculture on 140 million mu of black soil land in Northeast China and elsewhere. The main content of the Special Project “03 agricultural mechanization” includes establishing 300 demonstration counties for whole-process mechanization in crop production, establishing 300 demonstration counties for whole-process mechanization in protected agriculture and large-scale animal production, and promoting mechanized subsoiling operations and the suitable-for-mechanization transformation of farmland in hilly and mountainous areas.

2.2 A COMPLETE SYSTEM OF LAWS, REGULATIONS AND POLICIES FOR AGRICULTURAL MECHANIZATION

China has gradually established a system of laws and regulations for agricultural mechanization. In this system, the general guideline is the *Law on Promotion of Agricultural Mechanization of the People's Republic of China* (Adopted at the Tenth Meeting of the Standing Committee of the Tenth National People's Congress on 25 June 2004 and promulgated by Order No.16 of the President of the People's Republic of China on 25 June 2004) (China National People's Congress, 2018). The backbone is the Administrative Regulations of the State Council (e.g. *Regulations on Safety Supervision and Administration of Agricultural Machinery*) and local regulations based on departmental regulations and administrative regulations of the local people's government. Relevant laws, regulations and normative documents connect to and complement each other, and form a complete system of laws and regulations for agricultural mechanization in China (Figure 10).

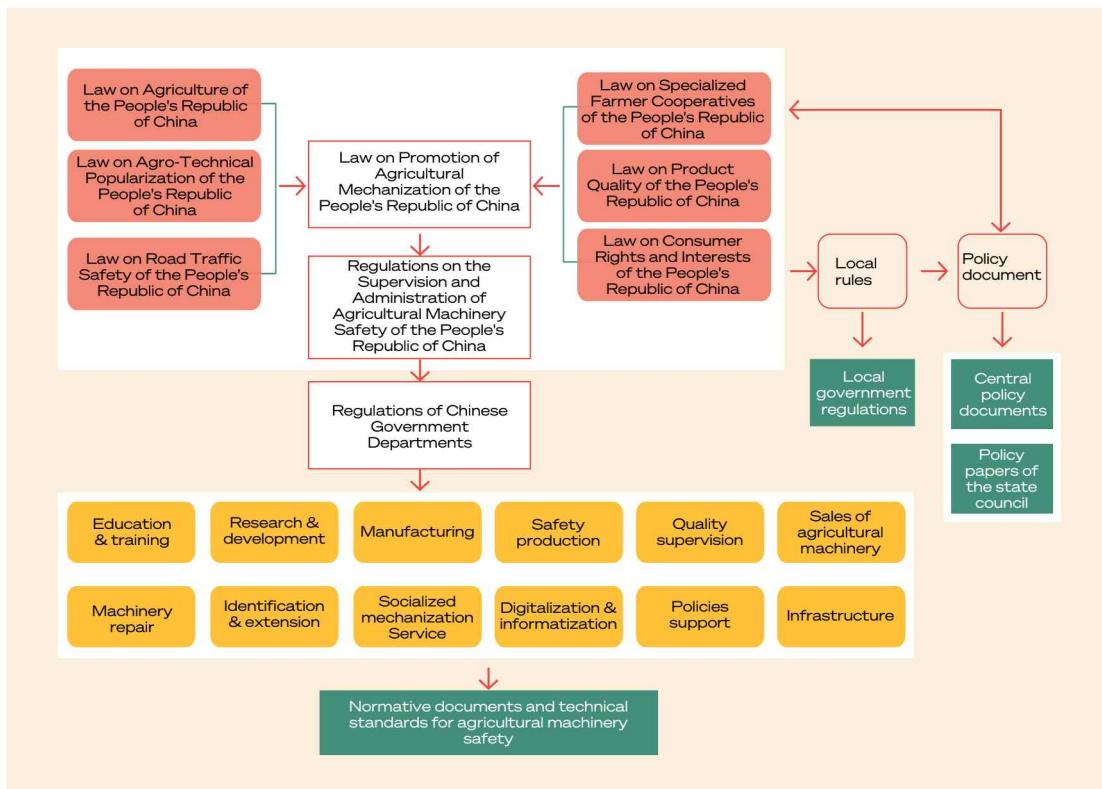


Figure 10

Schematic diagram of the framework of China's system of laws and regulations for agricultural mechanization

SOURCE: Authors' own elaboration.

At present, 13 laws and administrative regulations have been formulated at the national level, along with 10 departmental rules and regulations, eight normative documents, and 37 local agricultural machinery regulations jointly formulated by the Standing Committees of 29 Provincial People's Congresses across the country (including autonomous regions and municipalities directly under the central government). Nineteen provinces (including autonomous regions and municipalities directly under the central government) have issued 27 government regulations on the management of agricultural machinery.

2.2.1 Laws

The Law on Promotion of Agricultural Mechanization of the People's Republic of China (hereinafter referred to as the *Mechanization Promotion Law*), promulgated in 2004, occupies a leading position in the entire legal system for agricultural mechanization. Other relevant laws also contain some content concerning agricultural mechanization that also form the basis for and are components of the legal and regulatory system for agricultural mechanization. The relevant laws include the following:

- Law on Agriculture of the People's Republic of China;
- Law on Agricultural Rural Revitalization of the People's Republic of China;
- Law on Agro-Technical Popularization of the People's Republic of China;
- Law on Road Traffic Safety of the People's Republic of China;

- Law on Specialized Farmers' Cooperatives of the People's Republic of China;
- Law on Product Quality of the People's Republic of China;
- Law on Protection of Consumer Rights and Interests of the People's Republic of China.

2.2.2 Administrative legislation

The Eightieth Executive Meeting of the State Council in 2009 passed *Regulations on Safety Supervision and Administration of Agricultural Machinery* (hereinafter referred to as the *Machinery Administration Regulations*), which clarified the responsibilities, objectives and requirements necessary to strengthen agricultural machinery safety supervision and management, to prevent and minimize accidents during agricultural machinery operation, and to ensure the safety of people's lives and property. This is of great significance to ensure the safe, efficient and harmonious development of agricultural mechanization.

2.2.3 Local legislation

Based on the *Mechanization Promotion Law* and the *Machinery Administration Regulations*, many provinces formulated local laws and regulations with regional characteristics. Having local laws and regulations based on regional characteristics is an important part of the system for agricultural mechanization laws and regulations in China. Twelve provinces (autonomous regions and municipalities), such as Beijing, Shanxi, Inner Mongolia and Liaoning have formulated local regulations on the promotion of agricultural mechanization. Eighteen provinces, such as Tianjin, Hebei, Jilin and Inner Mongolia, have formulated local regulations on agricultural machinery administration. Six provinces have formulated local regulations on the supervision and administration of agricultural machinery safety (Jiangsu, Guangxi, Sichuan, Yunnan, Ningxia and Xinjiang).

2.2.4 Regulations of the Ministry of Agriculture and Rural Affairs

In accordance with the needs of implementing the *Mechanization Promotion Law* and the *Machinery Administration Regulations*, MARA has formulated supporting rules and regulations for agricultural machinery operations and management which cover almost all aspects of agricultural machinery quality management, safety management and accident handling. These regulations formulated by MARA include:

- Measures for the Administration of Tractor Driving Training;
- Measures for the Quality Investigation of Agricultural Machinery;
- Measures for the Administration of Cross-Regional Operations of Combine Harvesters;
- Regulations on Responsibility for Repair, Replacement, and Return of Agricultural Machinery Products;
- Measures for Handling Agricultural Machinery Accidents;
- Agricultural Machinery Test and Appraisal Measures;
- Provisions on Agricultural Machinery Maintenance;
- Provisions on the Administration of Tractor and Combine Driving Licenses;
- Provisions on the Registration of Tractors and Combines;
- Tractors and Machinery for Agriculture and Forestry-Technical Means for Ensuring Safety (GB 10395.6-2006);
- Technical Requirements of Operating Safety for Plant Protection Machinery (NY 1232-2006); and
- Plant Protection Machine General Requirements for Safety Certification (NY 1135-2006).

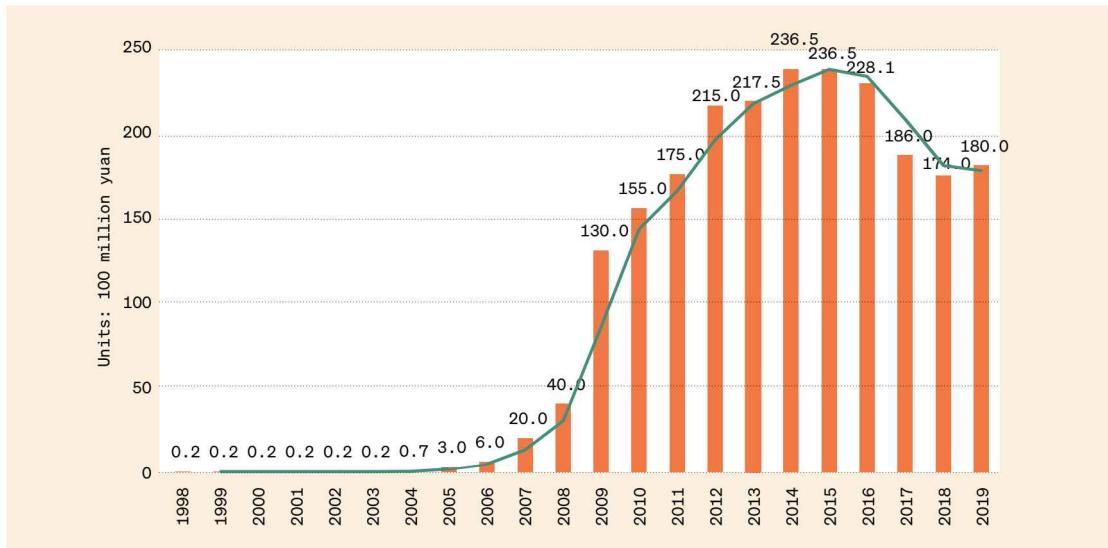


Figure 11

Changes from 1998 to 2019 in the annual amount of subsidies for the purchase of agricultural machinery from the central government fund

SOURCE: Authors' own elaboration.

2.2.5 Local government regulations

The people's governments of 19 provinces have issued 27 administrative rules on the management of agricultural machinery, related science and technology education, agricultural machinery production, sales and maintenance, test appraisal and extension, safety supervision, and more.

2.2.6 Normative document construction

Normative documents are the concrete embodiment of policies. In 1980, 1984, 1987, 1991, 2010, and 2018, the State Council issued documents on agricultural mechanization and the agricultural machinery industry. Provisions were made on the guidelines and related policies for developing wheat harvesting machinery, allowing tractors to operate on roads, developing agricultural mechanization and the agricultural machinery industry by adapting to local conditions, giving classified guidance, and making breakthroughs in key areas.

2.3 SPECIAL FUNDS TO SUPPORT AGRICULTURAL MACHINERY PURCHASE SUBSIDIES AND OPERATION SUBSIDIES SET UP BY THE CENTRAL GOVERNMENT AND PROVINCIAL GOVERNMENTS

2.3.1 Agricultural machinery purchase subsidies

From 1998 to 2003, the Chinese Government set up a special fund amounting to CNY 20 million per year for the upgrading of large tractors. In 2004, a special fund for agricultural machinery purchase subsidies was set up nationwide. By 2019, the central government had invested a total of CNY 220.58 billion (Figure 11) to guide and drive the extension and application of advanced, applicable and green agricultural machinery. To maintain the standardization and stability of the implementation of subsidy policies for agricultural machinery purchase, MARA and MOF formulate and promulgate the *Guiding Opinions on the Implementation of Agricultural Machinery Purchase Subsidies* every three years, in accordance

with the *Measures for the Administration of Agricultural Production Development Funds* (Cainong [2017] No. 41) and other relevant regulations.

On 6 April 2021, the General Office of MARA and the General Office of MOF jointly issued the *Guiding Opinions on the Implementation of Agricultural Machinery Purchase Subsidies 2021–2023* (MARA and MOF, 2021) aiming to guide the standardized implementation of policies on agricultural machinery purchase subsidies in various regions, giving full play to the policy benefits and promoting the transformation and upgrading of agricultural mechanization to a whole-process, high-quality, and high-efficiency process. This can effectively support food security and the efficient supply of major agricultural products, and increase rural incomes. It contributes to promoting high-quality and efficient development of agriculture and rural revitalization and accelerating the modernization of agriculture and rural areas.

(1) Key implementation areas

- Include all machinery and equipment needed for the production of important agricultural and livestock products such as grain and pigs.
- Promote the adoption of intelligent terminals and intelligent operation modes and deepen the extension and application of the Beidou system (BeiDou Navigation Satellite System, 2021) in agricultural production.
- Increase the amount of some key subsidies from 30 percent to 35 percent for machinery and equipment, including that required for weak links in crop production, for example, the rice seedling transplanter, heavy-duty no-tillage seeder and maize kernel harvester. The subsidies also cover new machinery and equipment as intelligent, multifunctional and high-end products that are urgently needed for the development of special agricultural product industries in hilly and mountainous areas.
- Gradually decrease the amount of subsidies to 15 percent or less by 2023 for wheeled tractors and other machinery and equipment that are obviously excessive in a region and relatively backward in technology. In addition, some low-value machinery and equipment will be withdrawn from the subsidy scope.
- Improve digitalization; promote the adoption of mobile applications, facial recognition, quick response (QR) code management of subsidized machinery and equipment, and internet of things monitoring technologies; and accelerate online processing of the entire subsidy process.

(2) The objects of subsidies

The objects of subsidies are individuals engaged in agricultural production and production and operation organizations.

(3) Scope of subsidized machinery and equipment

Agricultural machinery and equipment in the scope of central finance purchase subsidies cover 15 categories, 44 subcategories, and 172 items, mainly land preparation machinery, seeding/planting and fertilizing machinery, field management machinery, harvesting machinery, post-harvest processing machinery, processing machinery for primary agricultural products, agricultural handling machinery, drainage and irrigation machinery, livestock management machinery, aquatic product machinery, agricultural waste use and treatment equipment, farmland infrastructure machinery, facility agricultural equipment, power machinery (tractors), and others.

The implementation of the policy of subsidizing the purchase of agricultural machinery has aroused the enthusiasm of farmers to purchase and use it and subsidized the purchase of more than 23 million units/sets of various items of agricultural machinery and equipment. China has become the largest country in the world in the manufacture and use of agricultural machinery.

2.3.2 Implementing subsidies for mechanized subsoiling and soil preparation operations

Since 2006, mechanized subsoiling has been explored in Jilin Province, aiming to break the plough pan, deepen the topsoil, decrease soil bulk density, improve soil permeability and soil water storage, enhance tolerance of drought and resilience to flood, improve the soil environment of farmland that is conducive to the growth and development of crops, and increase yield.

The suitable areas for mechanized subsoiling in land preparation in China are mainly distributed in the agricultural regions such as the one-crop-a-year region in Northeast China, the double-cropping region in Huang-Huai-Hai Region, the wind-sand region along the Great Wall in North China, the Loess Plateau region in Northwest China, the oasis agricultural region in Northwest China, the dryland planting region in South China, and the sugarcane planting area in South China. The soil texture of subsoiling operations is clay and loam. The subsoiling cycle should be more than three years. In some agricultural regions, the subsoiling period and operation depth can be adjusted appropriately according to crop type, soil conditions and climatic conditions.

Monitoring data showed that plots with up to 30 cm of subsoiling can store about 400 cubic metres more water/ha than plots without subsoiling. The average water content during a drought period can increase by about 7 percentage points, the drought-tolerance period of crops can be extended by 10 days, and the average yield of wheat, maize and other crops can increase by about 10 percent. By the end of 2019, China had 1.2728 million units of large tractors of at least 80 horsepower and 4.3647 million units of subsoilers. The total area of mechanized subsoiling has reached 1.5 billion mu (100 million ha), which has greatly improved the ecological environment of farmland.

2.3.3 The Ministry of Agriculture and rural affairs provides subsidies for land trusteeship and agricultural mechanization hire services and operations

(1) In August 2017, the Guiding Opinions of the Ministry of Agriculture, the National Development and Reform Commission, and the Ministry of Finance on Accelerating the Development of Agricultural Production Service Industry were promulgated.

Agricultural production service refers to the socialized hire service along the whole process of agricultural production by direct operation or assistance in completing all links of agricultural operations before, during and after production.

The focus is on supporting agricultural products under the trusteeship service. Through specialized, large-scale and integrated agricultural hire services, the aim is to increase efficiency in the production of grain, cotton, rapeseed, sugar and other staple agricultural products and ensure the security of national agricultural production.

Another focus is on supporting agricultural operation links of the trusteeship service. In order to meet the needs of modern agricultural development and production, the key supporting areas of operation links and content in the trusteeship service will be identified in the region, and support will be prioritized for the operations identified.

Another focus is on supporting land trusteeship modes. Different trusteeship modes have been explored and formed, such as trusteeship for a single production link, trusteeship for multiple production links, comprehensive trusteeships for key production links, and full trusteeships for whole-process production, thus providing innovative and flexible hire service packages.

Another focus is on supporting large-scale service operation models as these have prominent economies of scale and drive more farmers. In the mountainous and hilly areas where it is difficult to achieve large-scale intensification, the focus is on supporting relatively large- to medium-scale trusteeship services.

(2) On 10 September 2019, MARA held an on-site promotion event on integrated agricultural hire services in Qihe County, Shandong Province.

In 2018, China's agricultural production trusteeship service area reached 92.27 million ha, an increase of 50 percent over the previous year. Service enterprises, farmers' cooperatives, collective economic organizations, agricultural enterprises, and other diversified service entities reached 370 000. Focusing on vigorously promoting the trusteeship of agricultural production, Shanxi Province explored the establishment of a trusteeship mechanism for promoting agricultural production throughout the county and issued a series of regulations for the trusteeship industry, directly serving 260 000 small farmers.

Some enterprises have joined the ranks of land trusteeship, such as the Modern Agriculture Platform (MAP) mode of the Sinochem Corporation, "KINGFARM" mode of Kingenta Ecological Engineering Group Co., Ltd., and the "technology integration + agricultural services" mode of Gansu Gufengyuan Agricultural Science and Technology Co., Ltd.

The central government invested CNY 4.5 billion in 2020 and CNY 5.5 billion in 2021 to promote large-scale operations and mechanization hire service development, which has significantly improved production efficiency and diminished production costs.

2.3.4 Some provinces have implemented agricultural mechanization operation subsidy policies to optimize local staple crop production

Some provinces in China have implemented these subsidy policies, funded by provincial finance in accordance with the actual production needs and weak links of mechanized operations in the respective regions. According to the geographic regions of China, this report introduces the main contents of agricultural mechanization operation subsidy policies in selected typical provinces, covering the Northeast region, the middle and lower reaches of the Yangtze River plain, the hilly and mountainous region in Southwest China, the hilly and mountainous region in North China, and the low hilly region in South China, among others. In most provinces, mechanized subsoiling and land preparation, mechanized straw returning, and farmland soil fertility protection and other related operations are included in the scope of agricultural mechanization operation subsidies. According to the crops and the development of mechanization in different regions, the agricultural mechanization operations subsidized by the provinces mainly involve mechanized rice transplanting, mechanized rapeseed harvesting, mechanized maize harvesting, and other weak links of mechanized operations for major crops. The level of subsidies for each operation is 20–30 CNY/mu. Some regions also provide subsidies for mechanized plant protection and post-harvest drying to promote the development of whole-process mechanization and machinery hire services.

SUITABLE-FOR-MECHANIZATION TRANSFORMATION IN HILLY AND MOUNTAINOUS AREAS IN SHANXI PROVINCE

Shanxi Province promulgated policy documents on suitable-for-mechanization transformation in hilly and mountainous areas, including *Technical Specifications for the Pilot Project on the Suitable-for-Mechanization Transformation in Hilly and Mountainous Areas of Shanxi*, *Notice on Docking Local Agricultural and Rural Departments as Soon as Possible to Implement Suitable-for-Mechanization Transformation of Farmland Included in the Well-Facilitated Farmland Construction in 2020*, *Guiding Opinions on the Implementation of the Pilot Project of Suitable-for-Mechanization Transformation in Hilly and Mountainous in 2019*, and the *Implementation Plan for the Pilot Project on Suitable-for-Mechanization Transformation in Hilly and Mountainous Areas in 2018*.

- In 2018, a subsidy fund of CNY 20 million was provided to 15 counties (districts) in 11 cities of Shanxi Province for the *Pilot Project on the Suitable-for-Mechanization Transformation in Hilly and Mountainous Areas*. The reconstruction area was 8000 mu (533.33 ha), with a subsidy of CNY 1500 to CNY 2000/mu (CNY 22 500 to CNY 30 000/ha).
- In 2019, Shanxi Province adopted engineering and technical measures for suitable-for-mechanization transformation in hilly and mountainous areas, covering an area of 10 000 mu (666.67 ha), with an average project fund subsidy of CNY 1500/mu (CNY 22 500/ha).



© CAU/Minli Yang



© CAU/Minli Yang

Suitable-for-mechanization transformation in hilly and mountainous areas in Shanxi Province.

SOURCE: Authors' own elaboration.

2.3.5 The suitable-for-mechanization transformation of farmland in hilly and mountainous areas

According to incomplete statistics, from 2019 to 2020 Chongqing, Shanxi, Hubei, Hunan, Guangxi, Gansu and other provinces invested a total of CNY 7.6 billion and guided social funds to support suitable-for-mechanization transformation of farmland in hilly and mountainous areas, and nearly 3.5 million mu (i.e. 0.2333 million ha) of farmland has been transformed. The total farmland areas of suitable-for-mechanization transformation in hilly and mountainous areas has reached 7.9 million mu (i.e. 0.5267 million ha). The working environment of agricultural machinery in farmland has improved significantly since the transformation. It is much more convenient for large- and medium-sized agricultural machinery to conduct various operations. The mechanized operating

SUITABLE-FOR-MECHANIZATION TRANSFORMATION IN HILLY AND MOUNTAINOUS AREAS IN HUNAN PROVINCE

Hunan Province has promulgated and implemented *Measures to Further Strengthen the Implementation of Policies on Agricultural Machinery Purchase Subsidies to Accelerate the Development of Agricultural Mechanization*.

- In 2019, the pilot project on the suitable-for-mechanization transformation of fruit, vegetable and tea fields was conducted in six counties (cities), including Shimen, Mayang and Xiangxiang.
- In 2020, financial funds of CNY 30 million were allocated to expand the pilot project to 15 counties (cities/districts) and the provincial financial department provided awards and subsidies of CNY 2 million to each pilot county (city/district). Each pilot county and city completed the suitable-for-mechanization transformation of more than 1600 mu (106.67 ha) of fruit, vegetable, and tea fields so as to achieve land interconnection, rational distribution of ditches and protection of soil fertility.



© CAU/Min Yang



© CAU/Ming Yang

Suitable-for-mechanization transformation in hilly and mountainous areas in Hunan Province.

SOURCE: Authors' own elaboration.

conditions are now mostly suitable for land preparation, planting, management, harvesting and transportation in hilly and mountainous areas. Soil water storage and fertility has improved significantly. In addition, the representative, guiding, and replicable demonstration of suitable-for-mechanization transformation has had outstanding effects. It has expanded the area of arable land, created conducive conditions for the application of agricultural machinery, promoted crop production, and ensured food security.

2.4 AGRICULTURAL MACHINERY AND EQUIPMENT TECHNOLOGY INNOVATION, EXTENSION AND APPLICATION

2.4.1 Intelligent agricultural machinery and equipment are included in the national key research and development plan

China attaches great importance to the research and development and industrialization of agricultural machinery and equipment. The mechanism combining "production, education, research, promotion, and application" has been established and alliances have been set up for agricultural machinery science and technology innovation in different fields. The basic research on agricultural machinery is led and organized by scientific research institutes and

SUITABLE-FOR-MECHANIZATION TRANSFORMATION IN HILLY AND MOUNTAINOUS AREAS IN CHONGQING

Chongqing has endorsed the suitable-for-mechanization transformation of farmland in *Chongqing Agricultural Mechanization Promotion Rules* and relevant provisions, and has promulgated and implemented *Technical Specifications for the Consolidation and Improvement of Hilly and Mountainous Plots in Chongqing*, *Financial Support Plan for Suitable-for-Mechanization Transformation of Farmland*, and the *Notice on the Compensation after the Construction of Suitable-for-Mechanization Transformation of Farmland*.

- Since 2016, Chongqing has strengthened the suitable-for-mechanization transformation of farmland.
- In 2017, Chongqing municipal finance allocated CNY 40 million, prompting resource partners to invest CNY 75 million to conduct the suitable-for-mechanization transformation of more than 100 000 mu of farmland in hilly and mountainous areas.
- By the end of 2018, a special fund of CNY 93 million was allocated for the suitable-for-mechanization transformation of 150 000 mu of farmland in more than 100 projects of 26 counties (districts).
- By the end of 2020, Chongqing had completed suitable-for-mechanization transformation of 800 000 mu (53 333 ha), which has increased the arable land area by 3–5 percent and greatly improved agricultural labour efficiency.



Suitable-for-mechanization transformation in hilly and mountainous areas in Chongqing.

SOURCE: Authors' own elaboration.

universities. The R&D and application of agricultural machinery products are led by agricultural machinery manufacturers. There is a trend to gradually encourage agricultural machinery manufacturers to become the main entities of scientific and technological innovation and thus accelerate the transformation of scientific and technological achievements.

(1) During the Eleventh Five-Year Plan (2006–2010), the projects listed in the National Key Research and Development Plan included *Research and Development of Large-Scale Agricultural Power and Operation Equipment Project*, *Research and Development of Multi-Functional Agricultural Equipment and Facilities Project*, and *Research on Intelligent Equipment and Technology for Modern Agricultural Machinery Project*.

(2) During the Twelfth Five-Year Plan (2011–2015), the projects listed in the National Key Research and Development Plan included *Intelligent Agricultural Machinery Technology and Equipment Project*, *Agricultural Precision Operation*

THE FIRST CHINA AGRICULTURAL MACHINERY EXTENSION FIELD DAY AND MECHANIZATION TECHNOLOGY TRAINING WORKSHOP (2016)

From 17 to 18 June 2016, the First China Agricultural Machinery Extension Field Day and Agricultural Mechanization New Technology Training Workshop was held in Zhucheng, Shandong Province. The theme of this event was cost saving and increasing efficiency in staple crop production, with the focus on areas such as mechanization solutions for high-end intelligent agricultural production and management of agricultural machinery, large feeding-volume grain harvesters, and whole-process mechanization solutions for potato production, all designed to promote the upgrading of whole-process mechanization of staple crop production.

During the field day, researchers fully demonstrated the modules of wheat harvesting, straw treatment, land preparation, and plant protection, through five activities that included operation demonstrations, interactive experiences, field experiments, operation fault identification, and skill competitions.



The First China Agricultural Machinery Extension Field Day and Mechanization Technology Training Workshop in 2016.

SOURCE: Authors' own elaboration.

Technology and Equipment Project, and Agricultural Water-Efficient Precision Control Technology and Products Project.

(3) During the Thirteenth Five-Year Plan (2016–2020), the projects listed in the National Key Research and Development Plan included *Intelligent Agricultural Machinery and Equipment*, aiming to realize the autonomy of core technology, enhance the intelligence level of high-end equipment, and improve the mechanization level of weak links in agricultural production.

(4) During the Fourteenth Five-Year Plan (2021–2025), the projects listed in the National Key Research and Development Plan included the *Key Technology of Industrialized Agriculture and Intelligent Agricultural Machinery and Equipment* special project, covering major aspects such as R&D of agricultural sensors, R&D of high-performance agricultural equipment (including intelligent equipment), and the application of unmanned technology.

2.4.2 Diversified investment in the promotion and application of agricultural machinery

Agricultural machinery enterprises, research institutions and agricultural mechanization cooperatives are supported and encouraged to participate in the extension of agricultural mechanization technology, and a mechanism for

CHINA AGRICULTURAL MACHINERY EXTENSION FIELD DAY AND MECHANIZATION TECHNOLOGY TRAINING WORKSHOP IN 2017

On 1 August 2017, the Agricultural Mechanization Technology Development and Extension Station of MARA, China Agricultural Machinery Distribution Association, Hebei Agricultural Mechanization Technology Extension Service Station, and LovoL Heavy Industry Co., Ltd., held the 2017 China Agricultural Machinery Extension Field Day and Agricultural Mechanization New Technology Training Workshop in Zhengding, Hebei Province.

- This field day focused on major agricultural structural reforms from the perspective of alternatives to staple grains, edible soybean, rapeseed, and “vegetable baskets”, and the crops included potato, soybean, peanut and cabbage. This demonstrated and promoted advanced and applicable agricultural mechanization technologies, such as power shift, air suction no-tillage seeding, high-speed transplanting, highly efficient plant protection, straw bundling and removing from the field, electronic monitoring of subsoiling, complex operations and precise operations. All of this demonstrated the integration of mechanization, agronomy, and digital technologies.
- The field day enriched and improved participatory and experiential extension methods, highlighted field practice training, and enhanced the capacity development of farmers and grassroots agricultural machinery extension personnel.
- More than 400 people attended the event, including leaders from 25 provinces and cities in agricultural machinery management and promotion departments. In addition, more than 230 people, including mechanization cooperatives and farmer machinery operators from Hebei Province, attended the field day.



China Agricultural Machinery Extension Field Day and Mechanization Technology Training Workshop in 2017.

SOURCE: **Press Office of MARA.** 2017. *The 2017 China Agricultural Machinery Promotion Field Day was held in Zhengding, Hebei province.* Cited 30 April 2021. www.moa.gov.cn/xw/zwdt/201708/t20170803_5768600.htm

collaboration and complementarity will be established and improved between public-welfare extension and profit-oriented extension. Innovative ways of experiential and participatory extension of agricultural mechanization technology have been implemented, such as field days of agricultural machinery extension and other forms.

Led by MARA, field days of agricultural machinery extension in China have been held annually since 2016, focusing on the weak links and challenges that have been mainly addressed in agricultural mechanization operations.

FIELD DAY IN 2018 THEMED PROMOTING THE WHOLE-PROCESS MECHANIZATION OF AGRICULTURAL PRODUCTION

On 15 May 2018, a field day with the theme “Promoting the Whole-Process Mechanization of Agricultural Production” was held in Nanchang, Jiangxi Province, co-organized by the Agricultural Mechanization Technology Development and Extension Station of MARA, Jiangxi Agricultural Mechanization Technology Extension and Monitoring Station, China Agricultural Machinery Distribution Association, Nanjing Research Institute for Agricultural Mechanization (NRIAM) of MARA, and Lovol Heavy Industry Co., Ltd.

- This field day focused on the key agricultural mechanization technology for fruit, vegetable, and tea production; key mechanization technology in hilly and mountainous areas; and the whole-process mechanization technology of grain and oil crops with comparative advantages, such as rice, rapeseed and peanut.
- This event placed the emphasis on field practice training and developed the capacity of new specialized farmers and technical staff.
- Through the field day platform, superior resources were gathered from extension agencies, enterprises, research and education institutions, and machinery associations and cooperatives, and a new mechanism was established for the extension of agricultural mechanization technologies that integrated production, education, research, promotion, and application.
- This explored integrated solutions for whole-process mechanization production of competitive agricultural products. It conducted demonstrations of mechanized operations for rapeseed, peanut and rice production, as well as field training and providing experience with new agricultural machinery operations.
- More than 500 agricultural machinery technicians, experts, association representatives, agricultural machinery production and marketing enterprise representatives, and local farmers enjoyed this agricultural machinery technology feast.



Promoting the Whole-Process Mechanization of Agricultural Production Field Day in 2018.

SOURCES: **Press Office of MARA.** 2018. *The 2018 China Agricultural Machinery Promotion Field Day was held in Nanchang, Jiangxi Province.* Cited 30 April 2021. www.moa.gov.cn/xw/zwdt/201805/t20180522_6142842.htm; **Agricultural Machinery News Network.** 2018. *The China Agricultural Machinery Promotion Field Day and Agricultural Machinery New Technology Training Activities opened.* Cited 30 April 2021. www.nongji1958.com/node/9398

CHINA AGRICULTURAL MACHINERY EXTENSION FIELD DAY AND MECHANIZATION TECHNOLOGY TRAINING WORKSHOP IN 2019

On 24 May 2019, the China Agricultural Machinery Extension Field Day and Agricultural Mechanization New Technology Training Workshop was held in Chuzhou, Anhui Province, organized by the General Station of Agricultural Mechanization Technology Development and Extension of MARA.

- Twenty-two agricultural machinery enterprises, 47 sets of machinery and equipment, and 23 kinds of integrated mechanization technologies were demonstrated in the field.
- The Agricultural Machinery Extension Station delivered professional lectures on the quality measurement of mechanized straw crushing and returning and mechanized rice transplanting.
- Academicians Luo Xiwen and Zhao Chunjiang of the Chinese Academy of Engineering and experts from China Agricultural University, Anhui Agricultural University, and Nanjing Agricultural Mechanization Research Institute conducted field training and guidance.
- The field day activities focused on demonstrations of mechanization solutions for the whole process of the oil crop and rice rotation system, and the mechanization technology of key links in the production of special cash crops.
- The activities included on-site operation demonstrations, field training, experience with the operations of new agricultural machinery, competitions for mechanized rice transplanting technology, experience sharing of suitable-for-mechanization transformation, and displays of agricultural hire service centres.
- More than 400 agricultural machinery technicians, representatives of agricultural machinery manufacturing and marketing enterprises, representatives of mechanization cooperatives, and farmers participated in the field day.



China Agricultural Machinery Extension Field Day and Mechanization Technology Training Workshop in 2019.

SOURCE: **Press Office of MARA.** 2019. *The 2019 China Agricultural Machinery Promotion Field Day was held in Chuzhou.* Cited 30 April 2021. www.moa.gov.cn/xw/zwdt/201905/t20190528_6315780.htm
CNR. 2019. *The 2019 China Agricultural Machinery Promotion Field Day was held in Chuzhou, Anhui Province.* Cited 30 April 2021. www.cnr.cn/ah/news/20190526/t20190526_524626729.shtml

2.5 CAPACITY DEVELOPMENT FOR AGRICULTURAL MECHANIZATION HIRE SERVICE PROVIDERS AND ORGANIZATIONS

Mechanization hire service refers to all kinds of agricultural equipment and machinery operation services offered to other agricultural producers along the agrifood value chain, provided by specialized farmers/households or hire service organizations (i.e. cooperatives or SMEs) that provide services such as mechanized land preparation, mechanized seeding/transplanting, mechanized harvesting, drainage and irrigation, and plant protection, as well as related agricultural

CHINA AGRICULTURAL INTELLIGENT MACHINERY AND EQUIPMENT FIELD DAY AND MECHANIZATION TECHNOLOGY TRAINING WORKSHOP IN 2020 (ON SITE AND VIRTUAL EVENT)

On 11 June 2020, the China Intelligent Agricultural Machinery and Equipment Field Day and Agricultural Mechanization New Technology Training Workshop was held in Zhao County, Hebei Province, organized by the General Station of Agricultural Machinery Testing and Appraisal of MARA and the General Station of Agricultural Mechanization Technology Development and Extension of MARA.

- The theme of the field day was “Intelligent Agricultural Machinery for Unmanned Agriculture”. A total of 13 integration modes, 23 agricultural machinery enterprises, more than 70 sets of machinery and equipment, and numerous pieces of intelligent equipment were used in on-site operation demonstrations.
- This showed the innovative R&D capacity and manufacturing level of agricultural intelligent, precision, and unmanned machinery and equipment in China.
- “Internet +” intelligent agricultural machinery and equipment showed the innovative production mode of modern agriculture and provided strong support for saving costs and optimizing productivity.
- Academicians Luo Xiwen and Zhao Chunjiang of the Chinese Academy of Engineering and other experts conducted field training and offered guidance.
- Academicians and experts gave lectures and answered questions in the field.
- There were demonstrations of agricultural UAVs for plant protection, sowing seeds, and surveying and mapping operations, as well as of the mechanization technology and equipment for cash crop production such as vegetables and sweet potato transplanting.
- The participating farmers experienced the intelligence and comfort of driverless tractors and harvesters in the fields.
- More than 300 participants attended the field day on site. The live webcast was watched by 500 000 people online.



China Agricultural Intelligent Machinery and Equipment Field Day and Mechanization Technology Training Workshop in 2020 (on site and virtual event).

SOURCE: **Press Office of MARA.** 2020. *The 2020 Smart Farm Equipment Field Day was held in Zhao County, Hebei Province.* Cited 30 April 2021. www.moa.gov.cn/xw/zwdt/202006/t20200616_6346530.htm

FIELD MEETING ON UNMANNED AGRICULTURAL MACHINERY OPERATION, BEIJING, 2021

On 24 May 2021, the Field Meeting on Unmanned Agricultural Machinery Operations was held in Beijing, jointly organized by the Agricultural Mechanization Management Office of the Beijing Municipal Bureau of Agriculture and Rural Affairs and the Beijing Agricultural Machinery Test, Appraisal, and Extension Station.

- The event provided an opportunity to display the latest progress of the integration of mechanization and digitalization (informatics) technology and succeeded in improving the extension and application of intelligent agricultural machinery and equipment in Beijing.
- There were demonstrations of unmanned tractor operations for land preparation, fertilization, seeding, plant protection, and landscape agricultural planting operations assisted by automatic driving technology.



© MARAJianZi

Field Meeting on Unmanned Agricultural Machinery Operation, Beijing, 2021.

SOURCE: **Ran Zi.** 2021. *Beijing held a Demonstration of Unmanned Agricultural Machinery Operation.* Cited 30 May 2021. www.came.net.cn/api/preview/1/269/77683

machinery repair and maintenance services, supply, intermediary, leasing, and other paid services. The hire services provide a profit-oriented business agricultural mechanization service, whereas the public service provides public welfare business agricultural mechanization services. The hire services and public services of agricultural mechanization combine with and complement each other; together, they constitute an important force to promote sustainable agricultural mechanization development in China.

2.5.1 Cultivating new service entities for agricultural mechanization hire services

The aim is to establish a multichannel, multilevel, inclusive, and diversified investment mechanism to support the development of new service entities for agricultural mechanization hire services. The investment mechanism will include financial funds as the guide, investment from individual farmers and agricultural production and operation service organizations as the main body, and other social investment as the supplement. Additionally, agricultural households with machinery

AGRICULTURAL MACHINERY PROMOTION FIELD DAY IN HEBEI PROVINCE IN 2021

On 9 May 2021, a field day was held in Cangzhou, Hebei Province with the theme of “Improving the mechanization level of forage (alfalfa) production and upgrading competitive industries”.

- Nearly 50 units of machinery and equipment for forage production from more than 30 domestic and foreign manufacturing enterprises demonstrated whole-process mechanized operations such as mechanized land preparation, plant protection, harvesting, closing, picking, and bundling for alfalfa.
- A workshop on mechanization in forage (alfalfa) production was held.
- This event further promoted the improvement of the mechanization level for forage (alfalfa) production and accelerated the comprehensive extension of whole-process mechanization technologies.



Hebei Province (Cangzhou) Agricultural Machinery Promotion Field Day in 2021.

SOURCE: **Zuolong Feng**. 2021. *Hebei Province in 2021 Agricultural Machinery Promotion “Field Day” Activities*. Cited 30 May 2021. www.came.net.cn/contents/269/76422.html

will be supported to develop into households specialized in mechanization hire services, and these households and peasants will be guided to establish agricultural machinery cooperatives and other service entities by bringing machinery and equipment, land, capital, and technology into the cooperatives. The establishment of agricultural mechanization cooperatives, joint-stock operating companies, regional agricultural machinery service centres, and agricultural machinery leasing companies has been actively supported and promoted.

2.5.2 Establishing a new service system for agricultural mechanization hire service

The aim is to establish a new socialized agricultural mechanization hire service system that covers the whole process of agricultural production and has comprehensive service content, flexible mechanisms, high operation efficiency, comprehensive support of machinery and equipment, and strong guarantee measures. The mechanization hire service system should include agricultural machinery service organizations as the main body and be based on households with machinery, connected by mechanization hire services. The main service content should include agricultural machinery operations, maintenance, supply, intermediary, and leasing services. Government support will guarantee the hire service system. In addition, it is crucial to develop the agricultural machinery operation market, foster agricultural machinery supply markets, develop agricultural machinery intermediary services, and meet farmers’ needs for the use of and investment in agricultural machinery.

YUNNAN SUGARCANE PRODUCTION MECHANIZATION AND MACHINERY EXTENSION FIELD DAY IN 2019

A Yunnan sugarcane mechanized production and machinery extension field day was held on 14 March 2019.

- This field day advocated for the integration of agricultural machinery and agronomy, the integration of mechanization and digital and information technology, the adaptation of mechanization hire services for moderate-scale agricultural operations, and the suitable-for-mechanization transformation of farmland.
- This event promoted the selection and extension of crop varieties suitable for mechanized operations and simplified production and integration of good varieties, technologies, land, and machinery for whole-process mechanization operations and large-scale production.
- The field day explored the “Yunnan Solution” for the mechanization of production of the major crops that were adapted to the plateau and mountainous areas of Yunnan Province.
- About 400 people participated in the on-site event.



© Mangshi Convergence Media Information Center

Yunnan Sugarcane Production Mechanization and Machinery Extension Field Day in 2019.

SOURCE: **Jian Ma.** 2019. *Yunnan: Successfully held Sugarcane Production Mechanization On-site Event and “Farm Machinery Promotion Field Day”*. Cited 30 May 2021. www.came.net.cn/contents/269/14316.html;

Mangshi Convergence Media Information Center. 2019. *2019 Yunnan Sugarcane Production Mechanization On-site Event and Farm Machinery Promotion Field Day were held in Dehong*. Cited 30 May 2021. <https://baijiahao.baidu.com/s?id=1628336750904297128&wfr=spider&for=pc>

2.5.3 Optimizing the mechanism of agricultural mechanization hire services

According to the requirements of specialized services, market-oriented operations and brand-based services, it is important to optimize the operation mechanism of agricultural mechanization hire services which work in line with scientific management, with high efficiency and integrity through the rational allocation of production factors by market mechanisms, and have clear ownership and responsibilities to stakeholders. In addition, the allocation mechanism should be fair and efficient and give full play to the potential productivity and management capacity of the agricultural mechanization service organizations.

2.5.4 Upgrading the quality of agricultural mechanization hire services

According to statistics, in 2019 China had more than 4.24 million specialized mechanized agricultural farm operations and 40.8 million employees of agricultural mechanization in rural areas. There were 192 000 agricultural

MECHANIZATION TECHNOLOGY OF STRAW RETURNING FOR PROTECTED AGRICULTURE FIELD DAY IN SHANDONG PROVINCE, 2019

On 20 June 2019, a mechanization technology of straw returning for protected agriculture field day was held in Weifang City, Shandong Province.

- The event mainly demonstrated the mechanized technical operation procedures of protected agriculture, including straw returning, subsoiling, land preparation, and soil pest management by ozone water.
- Sixteen sets from four types of machinery and equipment products were used in the operation demonstration.



Weifang Agricultural and Rural Bureau

Mechanization technology of straw returning for protected agriculture field day in Weifang, Shandong Province, 2019.

SOURCE: **Jingkun Wang and Mingyun Han**. 2019. *Nearly ten thousand greenhouses' straw will all return to the field*. Cited 30 May 2021. http://weifang.dzwww.com/wfxwn/201906/t20190627_16972577.htm

mechanization hire service organizations and providers. In addition, the total area of agricultural machinery services in China exceeded 800 million ha in 2019. The development of agricultural mechanization hire services is promoted in five ways: optimizing the resource allocation of agricultural machinery and equipment; boosting various forms of moderate-scale operations; enhancing development potential; improving the efficiency of management and services; and overcoming bottlenecks that restrict the development and growth of new entities. It is vital to establish mechanized family farms, agricultural mechanization cooperatives, and agricultural machinery operation enterprises that integrate agricultural production and mechanization services. It is important to build agricultural machinery maintenance service demonstration sites with strong support capability and application of energy-saving and emissions-reducing green technologies. It is also important to create mechanization cooperatives that can offer a complete range of equipment and facilities, have good operating mechanisms and management systems, provide large-scale service, and offer significant comprehensive benefits. Moreover, social capital should be guided to invest in the construction of multifunctional and integrated agricultural mechanization service centres.

DEMONSTRATION EVENT FOR THE MECHANIZED OPERATION FOR PRODUCTION OF FRUIT, TEA, MULBERRY AND HEMP IN THE HILLY AND MOUNTAINOUS AREAS IN SOUTH CHINA, 2018

On 28 November 2018, a demonstration event on mechanized operations for the production of fruit, tea, mulberries and hemp in the hilly and mountainous areas in Southwest China was held in Chongqing.

- The event mainly included the resource use of livestock and poultry manure, intercropping and green recycling of soil fertilization in orchards (suitable for mechanization transformation of farmland), as well as modern orchard cultivation modes such as fertigation systems and ground management.
- More than 1000 people watched the demonstration activities of related machinery and equipment on site.
- Through this event, items of advanced domestic and foreign agricultural machinery and equipment have been promoted and employed in the hilly and mountainous areas of South China, which has established a platform for cooperation and exchange for agricultural machinery research institutes and promoted the integrated development of agricultural machinery and agronomy.



© Northern Agricultural Machinery

Demonstration event of mechanized operations for the production of fruit, tea, mulberries and hemp in the hilly and mountainous areas in South China, 2018.

SOURCE: **Northern Agricultural Machinery**. 2018. 2018 Development Forum of Fruit, Tea, Mulberry and Hemp Production Mechanization and Agricultural Machinery and Equipment Demonstration Activities were held in Chongqing. Cited 30 May 2021. www.sohu.com/a/278437747_99905975

THE CONFERENCE ON THE ESTABLISHMENT OF COOPERATIVE CHAIRPERSON WORKING COMMITTEE OF COLLEGE GRADUATE PRACTITIONERS AND THE SIGNING CEREMONY OF THE STRATEGIC COOPERATION FRAMEWORK AGREEMENT

The Cooperative Chairperson Working Committee of College Graduate Practitioners provides a great platform for exchanging agricultural information and conducting in-depth research on the major issues in agriculture and mechanization.

- The Working Committee will evaluate and revise thematic areas and issues in the industry and formulate and publish standards.
- The Working Committee should actively organize public welfare activities and capacity development on poverty alleviation for rural areas, actively participate in international agricultural exchange activities, and play a leading role in the development of rural revitalization.
- The conference showed the spirit of the new development concept of shared development, cooperative development, and open development in the new era, and the idea of creating a “community of interests + responsibility + destiny” that is conducive to mutual benefit and win-win situations for agricultural business entities.
- The Working Committee signed a strategic cooperation framework agreement with Harbin Institute of Technology, Huida Technology Company, China Agricultural Producer Service Industry Alliance, the National Aviation Plant Protection Technology Innovation Alliance, and Beijing Shubo Zhiyun Information Technology Co., Ltd., to collaborate on the business model innovation of agricultural mechanization service organizations, and build a platform for cooperation and communication for the agricultural mechanization cooperatives managed by college graduate students.



The Conference on the Establishment of Cooperative Chairperson Working Committee of College Graduate Practitioners and the Signing Ceremony of the Strategic Cooperation Framework Agreement.

SOURCE: Authors' own elaboration.

2.5.5 Encouraging highly educated agricultural talents to engage in agricultural mechanization hire service

It is vital to improve the education and training systems for new vocational agricultural machinery operators and conduct large-scale capacity development for the chairpersons of agricultural mechanization cooperatives, operators, repair persons, and other practical personnel working with agricultural machinery. It is important to strengthen technical training for farmers by supporting the

development of mechanization hire service organizations and conducting various training courses and workshops.

On 26 October 2018, the Cooperative Chairperson Working Committee of College Graduate Practitioners (hereafter the “Working Committee”) under the China Association of Agricultural Mechanization was formally established in Wuhan. Currently, more than 70 chairpersons of farmers’ cooperatives are college graduates with a bachelor’s degrees or higher. With the Working Committee as a platform, these cooperative chairpersons further refined the production mode, formed the standards, and promoted green technology in agricultural production and new rural construction. Their new mission will also be uniting and leading the surrounding farmers and rural areas to adopt modern agriculture.

2.6 FOLLOW-UP ON THE QUALITY INVESTIGATION AND SUPERVISION OF AGRICULTURAL MACHINERY AND EQUIPMENT

In 2006, in accordance with the *Law on Promotion of Agricultural Mechanization of the People’s Republic of China*, MARA promulgated and implemented the *Measures for the Quality Investigation of Agricultural Machinery*. The agricultural machinery quality survey (hereinafter “quality survey”) refers to the activities organized by the administrative departments of agricultural mechanization of the provincial people’s government (or above) to investigate and supervise the suitability, safety, reliability and after-sales service status of specific types of agricultural machinery products.

MARA is in charge of the work on the national quality investigation of agricultural machinery products. According to the State Administration for Market Regulation of China (SAMR), MARA will unify the standards for quality investigation, coordinate transprovincial quality investigations, formulate and organize the implementation of the national quality investigation plan, and publish the investigation results of agricultural machinery products. SAMR organized and carried out national supervision and spot checks on the quality of agricultural machinery products (State Administration for Market Regulation, 2022).

The administrative departments of agricultural mechanization of the provincial people’s government are responsible for investigating quality within their respective administrative areas to formulate and organize the implementation of a quality investigation plan for their respective administrative areas and publish the investigation results.

The concrete work of quality investigation is undertaken by agricultural machinery test and appraisal institutions above the provincial level, with the cooperation of agricultural mechanization technology extension institutions, safety supervision institutions, and other institutions. Quality investigation must adhere to the principles of science, justice and openness, and should accept the scrutiny of users, producers, sellers of agricultural machinery and society. Specific quality investigation provisions include identification, implementation, and announcement of the quality investigation and related penalties.

2.7 THE CONTRIBUTIONS OF AGRICULTURAL MECHANIZATION TO AGRICULTURAL PRODUCTION, FOOD SECURITY AND EMPLOYMENT DURING AND AFTER COVID-19

2.7.1 Agricultural mechanization supporting spring farming during COVID-19

The spring of 2020 was the most critical period for global prevention and control of the COVID-19 pandemic. It was also a critical period for spring farming in China and the Northern Hemisphere. According to MARA, spring farming accounts for

more than half of the total annual crop production area in China. Therefore, spring farming is essential for food security and people's livelihoods.

As the first country to respond to the COVID-19 pandemic, China took a series of measures to control its spread and to restore agricultural production. Agricultural mechanization played a crucial role in restoring agricultural production, ensuring food security, and promoting employment during the COVID-19 pandemic. MARA promulgated a series of policies and guidance on mechanized agricultural production during the pandemic. During the 2020 spring farming period, MARA paid more attention to agricultural machinery used in agricultural production by strengthening organization and dispatch, increasing supply, coordinating and guaranteeing the transportation of agricultural machinery and equipment, and so forth. Investment covered a total of 22 million units (sets) of agricultural machinery and these were put into use during the spring of 2020, which was an increase of 300 000 units (sets) over 2019.

Some remarkable developments emerged in agricultural mechanization in China during the spring of 2020, such as online preparation for production, mechanization hire services, intelligent machinery and equipment, and green technology (MARA, 2020b):

- *Online preparation for agricultural production.* Through the online digital service stations of agricultural machinery, mobile apps, and other methods, online training, organization, and scheduling for agricultural machinery were achieved. In addition, farmers used the online system to complete the procedures for agricultural machinery purchasing subsidies, which ensured the implementation of supporting policies.
- *Mechanization hire service.* In the spring of 2020, more than 70 000 agricultural mechanization cooperatives across the country were engaged in agricultural production and provided hire services such as land preparation and seeding, one-stop whole-process mechanized production and integrated agricultural service. Additionally, innovative methods such as information and communication technology (ICT such as the “Didi Agricultural Machinery” app, and WeChat) further optimized mechanization hire service and machinery scheduling. The application of ICT in mechanization hire services helped large-, medium- and small-scale farmers to effectively connect with service providers, and thus increased efficiency and convenience and saved costs in production. Through the ICT-based hire service, farmers were able to complete agricultural production preparation without going out of their homes, so decreasing the need for personnel to gather and thereby allowing them to maintain social distance. Agricultural mechanization hire services not only solved the challenges of the labour shortage during the COVID-19 pandemic but also created local employment opportunities for migrant workers who could not travel.
- *Intelligent machinery and equipment.* In 2020, China employed more than 30 000 plant protection UAVs and more than 20 000 sets of autonomous-driving tractors and supporting equipment with Beidou navigation systems. The amount of intelligent machinery and equipment in 2020 increased significantly compared with previous years. The application of high-tech and intelligent equipment helped solve the problem of labour shortages and played an important role in reducing the need for farmers to meet in person, so contributing to the control and prevention of the pandemic.

- **Green technology.** The new types of agricultural machinery promoted the application of mechanized no-tillage, precision seeding, seedling throwing and transplanting, precision fertilization, and other green agricultural technologies in different cropping systems across China. One of the highlights was the promotion of conservation agriculture, a sustainable farming system. MARA and MOF jointly issued the *Action Plan for Conservation Agriculture of Black Soil in Northeast China (2020–2025)*. During the spring of 2020, about 45 000 units of high-performance no-tillage seeders for maize were put into use in Northeast China, covering a conservation agriculture area of more than 40 million mu (2.67 million ha). Conservation agriculture simplified agricultural production and contributed to the win-win situation of increasing productivity and protecting the ecological environment.

In general, departments of agricultural and rural affairs at all levels significantly contributed to promoting the online system, hire services, intelligent equipment, and green technologies of agricultural mechanization. Agricultural mechanization has played a crucial role in boosting agricultural production, guaranteeing food security, promoting green agriculture, and improving farmers' incomes and livelihoods.

2.7.2 Cross-regional mechanization operations in China during and after COVID-19

May 2020 marked the start of the summer agricultural activities of harvesting, planting, and management, especially for the wheat harvest. In April 2020, the Department of Agricultural Mechanization Management of MARA assessed the situation of cross-regional operations and estimated risks and challenges nationwide. In mid-May 2020, MARA held a nationwide virtual conference on the deployment of cross-regional operations of agricultural machinery in the summer (MARA, 2020c), including machinery supply, emergency work plans, support for cross-regional operations, promotion of new technologies and models of agricultural mechanization, and production safety. In order to decrease the impact of uncertain factors (such as pandemic developments and the weather) on the implementation of cross-regional operations of agricultural mechanization services, MARA issued the *National Emergency Response Plan for Cross-Regional Agricultural Mechanization Operations in 2020 Summer* (MARA, 2020e). Additionally, MARA and major wheat-producing provinces set up emergency teams to deal with cross-regional mechanization operations. They also clarified guidance on emergency situations, including public health, severe supply and demand imbalances for machinery, and extreme weather. This emphasized the need to strengthen information services such as the timely release of meteorological and epidemic information, updates on operational information, and feedback on problems. In addition, this highlighted the need to safeguard agricultural machinery operation oil, maintenance, supply of spare parts, operation settlement, the operator's life and accommodation, and so forth. All relevant departments and stakeholders collaborated to ensure the implementation of cross-regional agricultural mechanization operations and made important contributions to ensuring crop harvesting and food security.

2.7.3 Capacity development of farmers during and after COVID-19

In the early stages of the COVID-19 pandemic, A Letter to Farmers from MARA instructed farmers to strictly follow public health measures against the pandemic and to take early action to prepare for agricultural production in the spring,

including field management, fertilization and pest control, seedling preparation, and maintenance and repair of agricultural machinery. During and after the COVID-19 pandemic, MARA further implemented more flexible and convenient training methods by fully combining online and offline training. Some field training and workshops were conducted, but remote training methods were also adopted. Television and network cloud platforms were used to popularize agricultural knowledge and skills, interpret policies, and release information. High-quality training resources were also developed by agricultural colleges, research institutes and extension agencies. In 2020, online lectures presented information on how to strengthen agricultural products to ensure their supply during the COVID-19 pandemic, a policy interpretation of the *Action Plan for Conservation Agriculture of Black Soil in Northeast China (2020–2025)* and guidance on how to accelerate the development of hire services for agricultural production. In addition, through the training and popularization of ICT, farmers could use their mobile phones to book agricultural mechanization services in an effective manner and thus ensure agricultural production.

2.7.4 The contributions of agricultural researchers and scientists to agricultural production during and after COVID-19

During the critical period of the spring agricultural production in 2020, Chinese agricultural researchers, represented by a team of academicians and experts, actively took action to conduct monitoring and research, and they released timely production proposals, advice and guidance for various industries on carrying out agricultural activities during the COVID-19 pandemic (Farmers Daily, 2020). More than 600 000 agricultural technicians and experts from agricultural research, education and extension institutions took part. Simplified agricultural production technologies were advocated, such as no-till seeding (conservation agriculture) and the use of drone technology.

At the beginning of spring 2021, Professor Luo Xiwen, academician of the Chinese Academy of Engineering, contacted some the agricultural machinery departments, agricultural cooperatives and large-scale farmers of some provinces to learn about the impact of the pandemic on agricultural production. He proposed that each province should issue relevant policies to support the production and supply of agricultural inputs. He also suggested that planting operations should be adjusted appropriately according to local conditions, and he led the team in guiding the operations of precision direct seeding of rice in fields.

2.7.5 Farmer cooperatives' important contributions during and after COVID-19

During the Spring Festival in 2020, MARA issued *A Proposal to Farmers' Cooperatives Across the Country* (MARA, 2020d) to strengthen agricultural production and the food supply, increase farmers' income, and prevent and control the pandemic nationwide. The main measures involved were (1) strengthening the production and supply of agricultural products; (2) ensuring the quality of agricultural products and food safety; (3) enhancing sales channels, especially to urban markets; (4) maintaining good market order; (5) deploying strict pandemic prevention management; and (6) strengthening the personal protection of staff. Many agricultural mechanization cooperatives also used agricultural machinery or equipment such as unmanned aircraft (e.g. drones) with qualified operators, to support regional public hygiene activities.

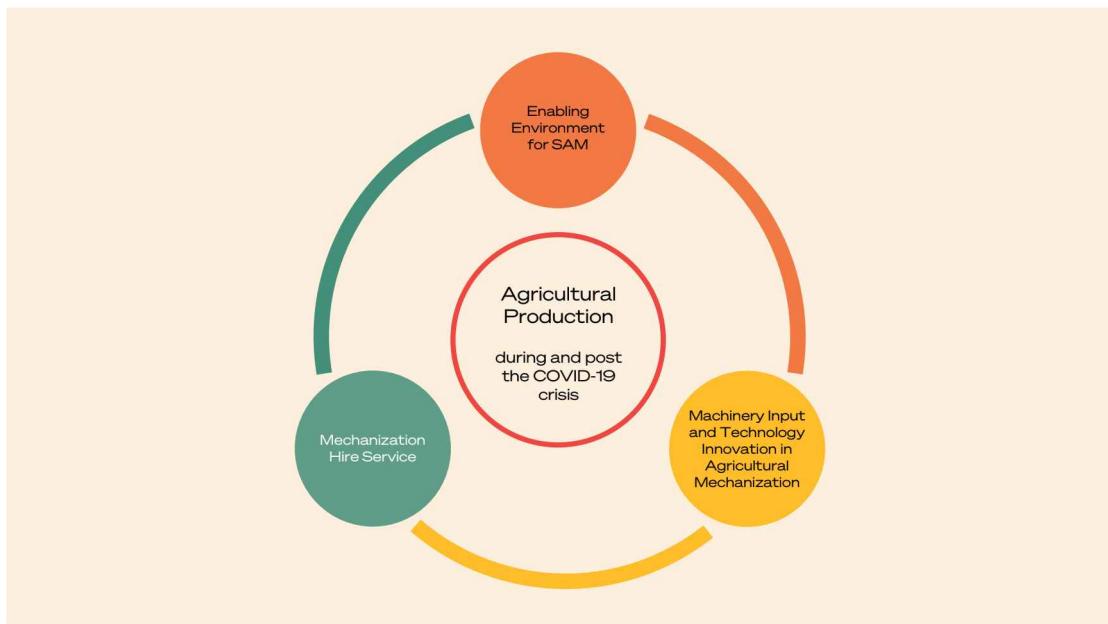


Figure 12

Sustainable agricultural mechanization (SAM) supports agricultural production during and after the COVID-19 crisis

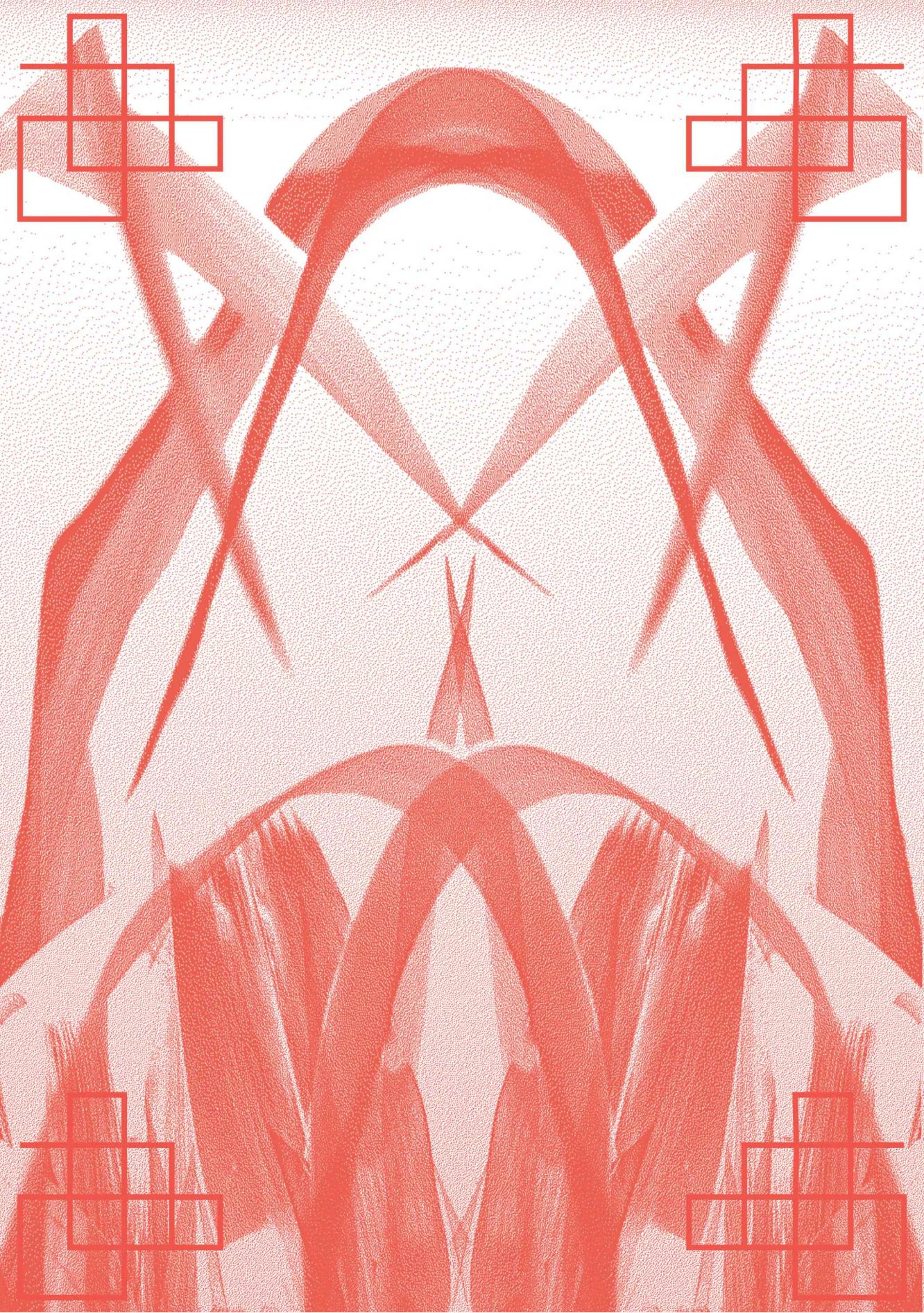
SOURCE: Authors' own elaboration.

2.7.6 Summary

- Smallholders should be prioritized, and they need to be at the core of the response strategies when restoring agricultural production during and after COVID-19. Service providers, farmers' cooperatives, large-scale farms, and private sector enterprises need to be made aware of this. Public-private partnerships (PPP), machinery and equipment inputs, technical support, and accessibility to mechanization hire services are essential to restoring agricultural production (Jiang and Kienzle, 2020).
- The private sector, that is new business entities for agricultural operations and services (mechanization hire service providers), is vital in implementing agricultural production and ensuring the food supply during and after COVID-19. This sector provides farmers with feasible and flexible services in crop production.
- Technology innovation in mechanization and hire services helps streamline production and increases productivity, improves the efficiency of dispatching machinery inputs and services, decreases the risk of farmers' having close contact during production, and thus contributes to the control and prevention of the COVID-19 pandemic.
- Promoting sustainable agricultural mechanization is still feasible during and after the pandemic. Sustainable agricultural mechanization can save labour and increase productivity and enable the long-term sustainability and resilience of the entire agricultural system and agrifood value chain (Figure 12).







Chapter 3

Challenges

The demand and structure of mechanization in various fields of agricultural production are undergoing profound changes in China, and the demand from Chinese farmers for mechanized production has become more and more extensive and urgent. Although China's agricultural mechanization has developed rapidly, it still faces a series of challenges in different regions, industries, varieties and operation links. The problems of imbalanced and inadequate development are also more prominent. Weak areas of agricultural mechanization have become more obvious, including agricultural machinery R&D, manufacturing and application, public management of agricultural mechanization, hire services, land operation scale, and agricultural machinery use efficiency. Therefore, the challenges of strengthening the weak links and promoting coordination have become more arduous.

3.1 CHALLENGES IN AGRICULTURAL MACHINERY R&D AND MANUFACTURING

Compared with developed countries, there are still big gaps in aspects of key machinery technologies, parts, materials, manufacturing processes, and major equipment. For example, precision sensors, control valves and control software rely on imports, and the steel variable-speed tractor technologies are not well-developed (e.g. electric control gear shifts, strapping and knotting devices, and variable motors). The level of the agricultural machinery industry is not high. More than 90 percent of domestic machinery and equipment consists of middle- and low-end products, while 80 percent of high-end machinery and equipment is imported. In addition, the production capacity of middle- and low-end products is excessive and very homogenized.

3.1.1 Imbalanced product structure of agricultural machinery and equipment

The range of agricultural machinery and equipment produced in the major developed countries covers the whole process of agricultural production. Although China is a big country for agricultural machinery manufacturing and consumption, agricultural machinery and equipment production is mainly focused on field operations for grain crops. The structural contradictions of agricultural machinery products in China include the following:

- too much agricultural machinery and equipment for staple grain production (i.e. wheat, rice and maize);
- too much agricultural machinery and equipment for the plains area of North China;
- too much agricultural machinery and equipment for crop production;
- too much small-power, middle-/low-end, or single-function agricultural machinery and equipment;
- insufficient machinery and equipment for cotton, oil, sugar, tea and other economic crop production;
- insufficient machinery and equipment for hilly and mountainous areas in South China;
- insufficient machinery and equipment for animal husbandry, fisheries, primary processing of agricultural products and facility agriculture; and
- insufficient large-scale, high-end, high-efficiency, multifunctional machinery and equipment.

Additionally, there are also challenges in manufacturing quality and materials for machines and core parts, which may result in poor durability of components, premature breakdowns, increased maintenance costs and hence low competitiveness with imported machinery. Furthermore, poor manufacturing quality and deficiencies in materials may also result in low operational performance of machines and may affect human safety and environmental security.

3.1.2 The leading role of enterprises has not yet emerged

China's agricultural machinery industry is characterized by a low degree of concentration, small enterprise scale, low industry profit, and low R&D investment. Most of the agricultural machinery enterprises have not yet played a major role in scientific and technological innovation, and the main challenge is the lack of motivation for innovation, such as weak technical force, inadequate research conditions, and insufficient technical reserves.

3.1.3 The effective supply of some machinery and equipment is insufficient

Most foreign tractors are more than 600 horsepower and all of them have power shift and continuously variable transmission (CVT) speed technologies. However, domestic tractors in China are mainly medium- and low-horsepower with mechanical shift, and the R&D into CVT technology has only just started. Additionally, harvesters with large feed capacity mainly rely on imports, such as grain combine harvesters with a feed capacity of more than 15 kg/second and high-efficiency silage harvesters with a feed capacity of more than 30 kg/second.

3.2 CHALLENGES IN THE PROMOTION AND APPLICATION OF AGRICULTURAL MECHANIZATION

From the perspective of regional mechanization development: Mechanization development is rapid in the dryland areas of North China. Nevertheless, mechanization development is slow in the paddy field areas of South China, especially in the hilly and mountainous areas of Southwest China. In addition, the comprehensive mechanization rate of crop production and harvest is less than 50 percent in four typical hilly and mountainous provinces in China.

From the perspective of industry: The mechanization level is high in the production of staple crops but low in the key production links of cash crops (e.g. cotton, oil, sugar, vegetables and tea), animal husbandry, fisheries, primary processing of agricultural products, and protected agriculture. The mechanization level of animal husbandry is only 34 percent and, although large-scale farms have achieved mechanization, the degree of mechanization is still low for the small- and medium-sized farms that account for 70 percent of farms.

From the perspective of quality: The varieties, agronomic systems, planting and breeding methods, scale, post-production processing, and other factors of some sectors of the agricultural industry are uncoordinated with mechanization. The low integration of agricultural machinery and agronomy seriously restricts agricultural machinery R&D, extension and adoption, and operational quality and benefits. The current integrated support for mechanized production systems and solutions is insufficient to meet actual production needs.

3.3 CHALLENGES IN THE PUBLIC MANAGEMENT OF AGRICULTURAL MECHANIZATION

Although some information service platforms and management systems for agricultural machinery have been established, some challenges still exist, such as inconsistent standards of platform construction in different regions and difficulties in data sharing. It is also important to improve the digitalization and IT level of machinery management and the monitoring and supervision of machinery operations.

3.4 CHALLENGES IN THE HUMAN RESOURCES OF AGRICULTURAL MACHINERY HIRE SERVICES

By the end of 2018, there were 47.586 million agricultural machinery employees in rural China, of which 11.414 million (accounting for 24 percent) held tractor driving licenses, 1.23 million (accounting for 2.4 percent) had combine harvester driving licenses, and 795 000 (accounting for 1.67 percent) held both licenses. Additionally, there were 930 700 personnel (accounting for 2 percent of machinery employees) working in agricultural machinery maintenance and 289 500 of them held a professional qualification certificate.

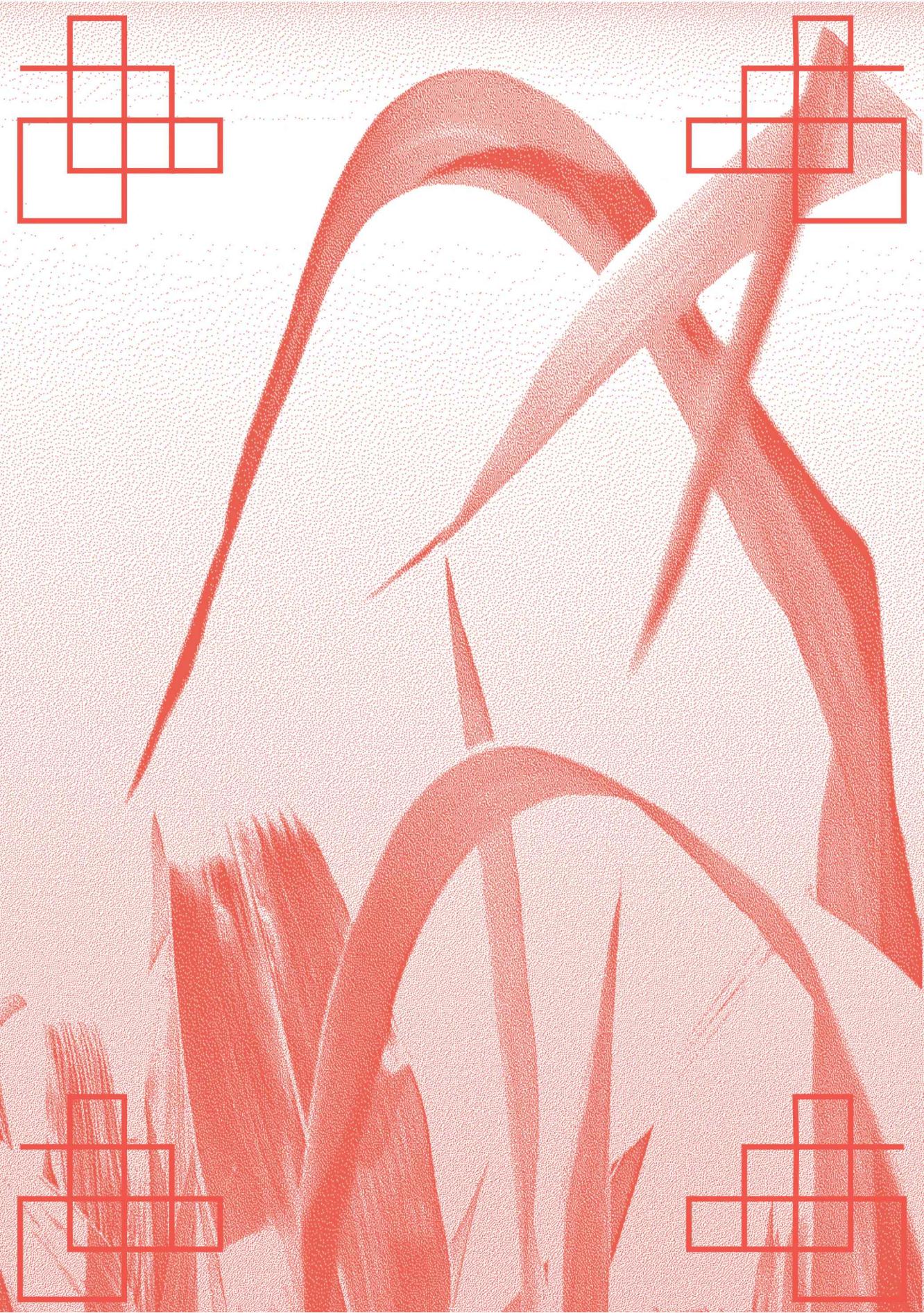
However, there is a serious shortage of practical and skilled personnel at the grassroots level. According to a survey of the education level of agricultural machinery operators in the sector, graduates from technical secondary school and junior college accounted for about 5 percent, high school graduates about 23 percent, middle school graduates about 50 percent, and graduates from primary school and below for 22 percent. With the application of high-tech in agricultural machinery and equipment, the development trend of mechanization will move towards high performance, intelligence and digitalization. There is an urgent need for a larger number of agricultural personnel in the field of agricultural machinery technology and innovative management, service and technical consulting.

3.5 CHALLENGES IN LAND MANAGEMENT SCALE AND AGRICULTURAL MACHINERY USE EFFICIENCY

According to a survey in 2017, the average total arable land area of smallholders was about 0.5 ha, the average total arable land area of large-scale farmers (growers) was about 6.8 ha, and the average total arable land area of a family farm was about 11.8 ha. The survey was carried out as part of the research project *Plant and Breeding Industry Production Equipment and Facilities Engineering – Agricultural Mechanization Engineering* sponsored by the Ministry of Science and Technology of China and the National Key R&D project *Integration and Demonstration of Key Technologies for Appropriate Scale Full Mechanization of Main Grain Crops in Hilly Areas*. The data covers 255 counties of 28 provinces (autonomous regions and municipalities), including different regions in North and South China. A total of 4678 samples were surveyed, including smallholders, large-scale growers/farmers and family farms. The sample numbers of smallholders, large-scale farmers and family farms were 2807, 1123 and 748, respectively.

Small-scale farmers will still be the mainstay of China's agricultural production. In the next few years, it will be impossible to achieve large-scale land management for all Chinese farmers. Based on the changed rule of land management scale in China since 1949, it is estimated that the proportion of large-scale farmers will increase by only about 5 percent of the total number of farmers. In fact, large-scale farmers in China accounted for less than 2 percent of all farmers in 2016. If this proportion rises to 5 percent, based on calculations of the average operation scale of large-scale farmers, the total area of farmland operated by large-scale farmers will account for nearly 48.4 percent of the total arable land in China; whereas, based on calculations of the current average size of family farms, that figure would rise to 83.9 percent. It is clear that China's agricultural production in the future depends not only on family farms and large-scale farmers but also on numerous small-scale farmers.





Chapter 4

Opportunities and main trends

In recent years, significant opportunities have created an enabling environment for accelerating the development of sustainable agricultural mechanization, including the Chinese Government attaching great importance to its development, accelerating the process of agricultural and rural modernization, and implementing the strategy of rural revitalization. The agricultural machinery industry is thus on the road to high-quality development.

4.1 OPPORTUNITIES

4.1.1 The Chinese Government attaches great importance to agricultural mechanization

In 2021, the *Opinions of the Central Committee and the State Council on Comprehensively Promoting Rural Area Revitalization and Accelerating Agricultural and Rural Modernization* (Xinhua News Agency, 2021c) clearly proposed “to improve the capacity for independent research and development of agricultural machinery and equipment” and called for accelerating efforts to make up for the shortcomings of modern agricultural input equipment such as agricultural machinery, especially by strengthening independent R&D for key agricultural equipment. The State Council issued relevant documents, held instrumental meetings, and repeatedly stressed the need to vigorously promote agricultural mechanization.

On 29 December 2018, the State Council issued the *Guiding Opinions of the State Council on Accelerating Agricultural Mechanization and the Transformation and Upgrading of Agricultural Machinery and Equipment Industry* (Guofa [2018] No. 42) (Chinese State Council, 2018), emphasizing that agricultural mechanization, machinery and equipment are the foundation for transforming

agricultural development and improving productivity in rural areas, and play critical roles in implementing the rural area revitalization strategy. This clearly stated the goal of agricultural mechanization development for 2025, including ensuring that objectives are met in areas such as agricultural machinery and equipment, the coordinated development of the key agricultural machinery products and key parts, reaching advanced levels of product quality and reliability, maintaining a sufficient supply of products and technology, and achieving high-quality development of the agricultural machinery and equipment industry. Additionally, the total power of agricultural machinery nationwide should be stable at around 1.1 billion kilowatts. The agricultural machinery and configuration structure should be more rational. It is important to improve agricultural machinery operating conditions and use efficiency, and to establish the mechanization hire service system covering the whole process from production to post-harvest. Agricultural mechanization will enter a period of whole-process, high-quality, and efficient development. The national mechanism for coordinating the development of agricultural mechanization led by MARA and MIIT will be optimized.

4.1.2 Speeding up the process of agricultural and rural modernization and implementing the rural area revitalization strategy

The transfer of agricultural labour has accelerated. The aging trend of the rural labour force is obvious with a shortage of young and middle-aged labour. Furthermore, the labour cost of agricultural production is rising annually. With continuous urbanization in China, migration to urban areas by the new generation of rural dwellers is resulting in a shortage of agricultural labour. According to a survey, the average age of China's agricultural labour force is 46; 67.5 percent are between 40 and 60 years of age, with only 4.8 percent born in the 1980s. There are insufficient agricultural talents in technical, business and service industries as well as in the central and western regions, remote mountainous areas, and impoverished areas. There is a most urgent need to replace human and animal labour with agricultural mechanization, which provides broad space for the development of whole-process mechanization along the agrifood value chain.

4.1.3 Agricultural machinery industry enters the stage of high-quality development

Scientific and technological innovation capability continues to improve in the agricultural machinery and equipment industry. New technologies, new products, new services, new models, and new businesses continue to emerge. The popularization of informatization and digitalization, intelligent machinery, and artificial intelligence (AI) technology is accelerating. The independent controllability of the supply chain and industrial chain is being continuously enhanced, which lays the material and equipment foundation to meet the need for mechanization in various fields. The development directions of global agricultural machinery and equipment are moving towards approaches that are large scale, multiple function, focus on energy saving and efficiency, intelligence, and precision, and that can provide integrated, systemic, intelligent, and digital solutions for mechanization development.

4.2 MAIN TRENDS

4.2.1 Using innovation as the driving force to make up for shortcomings

Technical, institutional and policy innovations will be continuously promoted in agricultural mechanization technology and extension, mechanization hire services, management systems, and support policies. The level of agricultural

machinery R&D, manufacturing and extension is constantly improving. Advanced technology and management experiences from other countries have been actively introduced. Innovations are the driving force to make up for shortcomings in machinery and equipment, whole-process mechanized production, and the mechanization of hilly and mountainous areas.

4.2.2 Promoting mechanization along the agrifood value chain and developing it from all aspects

Whole-process mechanization will be systematically planned in the production of major crops and breeding varieties, and the integration of varieties, cultivation methods, land and machinery will be optimized. The coordination of technology, multistakeholders, operation scale and mechanisms will be enhanced. A technical system for whole-process mechanization is developing along the agrifood value chain at the industrial and regional level.

4.2.3 Government support led by markets

Markets have been playing an increasingly important role in the allocation of resources. In addition, the government attaches great importance to agricultural mechanization, and has responded by continuously enhancing related policies to support the process. Institutional reform of management mechanisms has been advanced to improve the supply of public services, stimulate the vitality of market entities, enhance the R&D of manufacturers, motivate farmers' willingness to purchase, and constantly improve the quality and efficiency of mechanization services.

4.2.4 Systemic concept and green development

Overall planning, promotion, strategic layout and coordination are key to the systemic development of mechanization. It is also important to enhance the coordination of agricultural machinery, agronomy, farmland and operation modes in the light of local conditions. The integration of mechanization, digitalization and AI technology is being strengthened. Furthermore, China continues to enhance independent R&D capacity, strengthen the industrial chain and supply chain, and increase resilience to and mitigation of disasters. The green development of mechanization in China is unifying development quality, structure, scale, speed, effectiveness, and safety, as well as ecological sustainability.



Chapter 5

Development goal and path

This section discusses the development goal and path of sustainable agricultural mechanization in China. The development goal contains the main goals for 2025 and the long-term goals for 2035. The development path of China's agricultural mechanization mainly involves “two integrations” (the integration of mechanization and agronomy, and the integration of mechanization and digitalization); “two adaptations” (the adaptation of mechanization hire service mode to moderate-scale operation, and the adaptation of mechanized production to farmland construction; and “three accelerators” (technological innovation, institutional innovation and policy innovation).

5.1 MAIN GOALS FOR 2025

By 2025, the total power of agricultural machinery nationwide will be stable at about 1.1 billion kW (1100 GW). The configuration structure of agricultural machinery in China will become more rational; machinery operating conditions will be significantly improved; the mechanization hire service system covering the whole process of pre-production, during harvest and post-harvest will be established and optimized; and the use efficiency of agricultural machinery will be significantly improved. The comprehensive mechanization rate of crop production and harvesting will reach 75 percent nationwide and 55 percent in hilly and mountainous areas (counties, cities, or districts). The overall mechanization rate of protected agriculture, animal husbandry, aquaculture and primary processing of agricultural products will exceed 50 percent. The index system for evaluating the comprehensive mechanization level of various sectors of the agricultural industry will be mostly established in line with agricultural and rural modernization. Agricultural mechanization industrial clusters and industrial chains will be further consolidated, and the total revenue from agricultural machinery services will exceed CNY 500 billion (Table 12).

Table 12

Expected values of China's agricultural mechanization development goals in 2025 and 2035

S.no.	Indicator	Unit	Value in 2019	Expected value in 2025	Expected value in 2035
1	Total power of agricultural machinery	100 GW	10.28	11	13
2	Comprehensive mechanization rate of crop production and harvesting	%	70	^75	^90
3	Mechanization rate of livestock breeding	%	34	^50	^70
4	Mechanization rate of aquaculture	%	30	^50	^70
5	Mechanization rate of primary processing of agricultural products	%	38	^50	^70
6	Mechanization rate of protected agriculture	%	38	^50	^70
7	Mechanization rate of fruit/tea	%	25	^40	^60
8	Comprehensive mechanization rate of crop production and harvesting in hilly and mountainous counties (cities, districts)	%	49	^55	^70
9	Total income from agricultural mechanization hire services	100 million CNY	4 723	^5 000	^7 000
10	Agricultural labour productivity	CNY	36 200	54 300	81 450–108 600

SOURCE: MARA. 2021. *Notice of MARA on Printing and Distributing the National Agricultural Mechanization Development Plan in the Fourteenth Five-Year Plan*. Cited 30 January 2022. www.gov.cn/zhengce/zhengceku/2022-01/06/content_5666677.htm

5.2 LONG-TERM GOALS FOR 2035

By 2035, China's agricultural mechanization should have made decisive progress. The production of major crops will be mechanized in the whole process and the level of mechanization of livestock, poultry, aquaculture and fisheries will have risen sharply. Mechanized agricultural production will mostly cover various agricultural areas and regions. The mechanization of protected agriculture will have improved. In addition, the value-added capabilities of agricultural products will have been significantly enhanced by the mechanized primary processing of agricultural products. An efficient mechanized production system will have been established, with the application of "mechanization + digitalization" in the whole process of production, management, operation monitoring and services. Sustainable agricultural mechanization will also comprehensively support the development of agricultural and rural modernization.

5.3 DEVELOPMENT PATH

The mechanization development path has the objectives of serving the implementation of the rural area revitalization strategy and meeting the needs for mechanized production and agricultural and rural modernization. It will promote and deepen the supply-side structural reform of agricultural mechanization and enhance the core technologies and R&D of intelligent machinery and equipment. It will strengthen the linkages of agricultural industries, education/research/extension institutes and markets, promote the construction of national technological innovation centres or engineering centres for digital agriculture and intelligent machinery, and explore pilot projects for unmanned farms, pastures, or fishing grounds. It is vital to promote the adaptation of mechanization for mixed farming, intelligent ICT, agricultural operations and management, and well-facilitated farmland construction, and establish the framework for a mechanized agricultural production technology system based

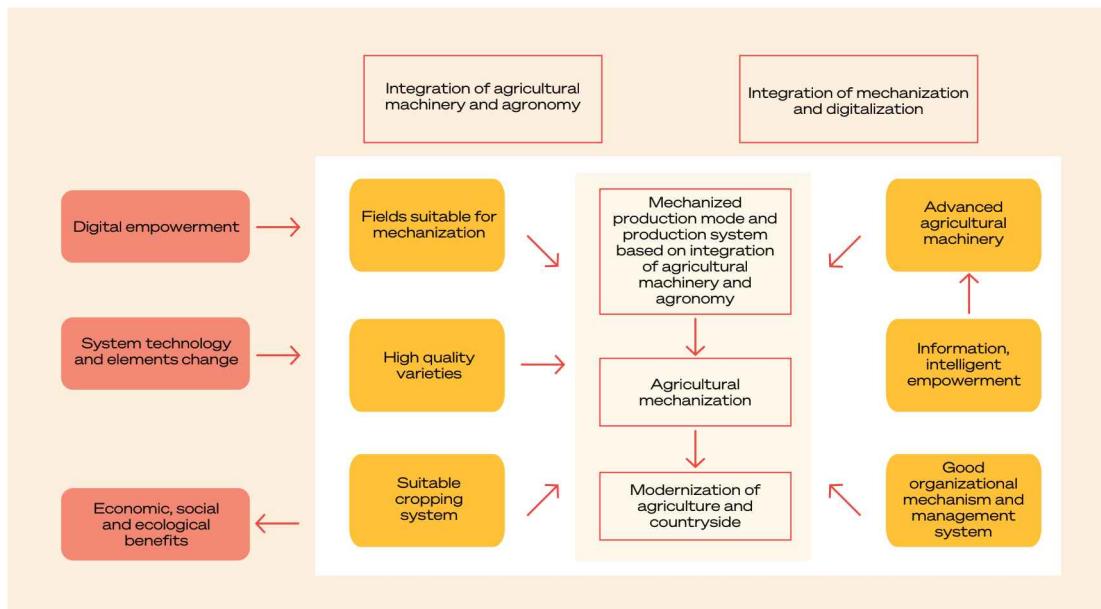


Figure 13

Framework of agricultural mechanization production technology system based on the integration of mechanization and agronomy and integration of mechanization and digitalization

SOURCE: Authors' own elaboration.

on the integrations of mechanization and agronomy as well as integration of mechanization and digitalization (Figure 13).

Scientific, technological, institutional and policy innovations will drive the development of a high-quality and high-efficiency agricultural mechanization system. This will further ensure the effective supply of important agricultural products, consolidate and accelerate the development of the agricultural industry in impoverished areas, and provide strong support to agricultural and rural modernization and revitalization. Figure 14 shows the development path of agricultural mechanization in China.

5.3.1 Two integrations

The development path of sustainable agricultural mechanization highlights the integration of mechanization and agronomy as well as the integration of mechanization with digitalization and informatics.

The integration of mechanization and agronomy emphasizes that issues such as varieties, tillage modes (i.e. conservation agriculture), cropping systems, field management, breeding methods, and processing must be addressed by specific types of mechanization. Appropriate agricultural machinery, equipment and technology extension modes should be applied to build a whole-process mechanized production system.

The integration of mechanization and digitalization means applying digital and information technologies to agricultural mechanization production, services, and management, including the internet, internet of things, big data, ICT, automatic control, satellite positioning, and others. This will comprehensively improve the quality and level of agricultural machinery manufacturing, products, services, and management.

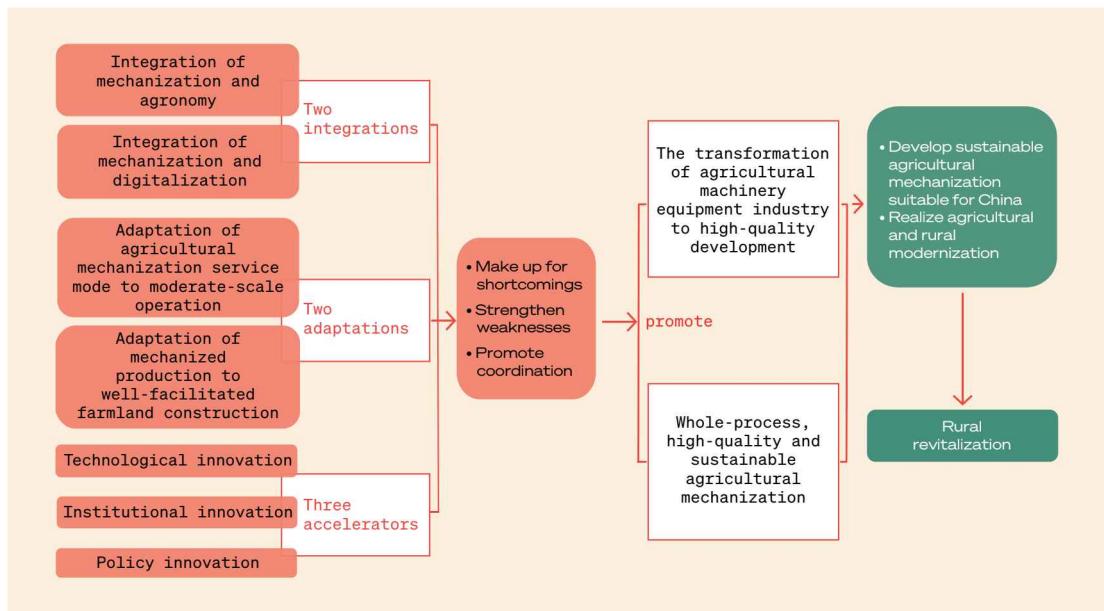


Figure 14
Development path of sustainable agricultural mechanization in China

SOURCE: Authors' own elaboration.

5.3.2 Two adaptations

Adaptation of the mechanization hire service model to moderate-scale agricultural operations. This hire service cannot only provide large-scale and efficient agricultural mechanization services for centralized-scale operations under land circulation but must also provide unified service operations in scattered lands and lead the development for small-scale farmers.

Adaptation of mechanized production to farmland construction. This will be a transformation from the traditional “machinery adapting to the field” to “machinery and field adapting to each other”. The relevant systems, standards, norms, and implementation rules should be formulated and optimized for the consolidation of suitable-for-mechanization transformation of farmland. Additionally, it is important to clarify the related specific requirements such as the length, width, and flatness of fields and field tracks to effectively improve the transportation and operating conditions of agricultural machinery, and to improve the adaptability of agricultural machinery to fields. The suitable-for-mechanization transformation of farmland in hilly and mountainous areas will be prioritized.

5.3.3 Three accelerators

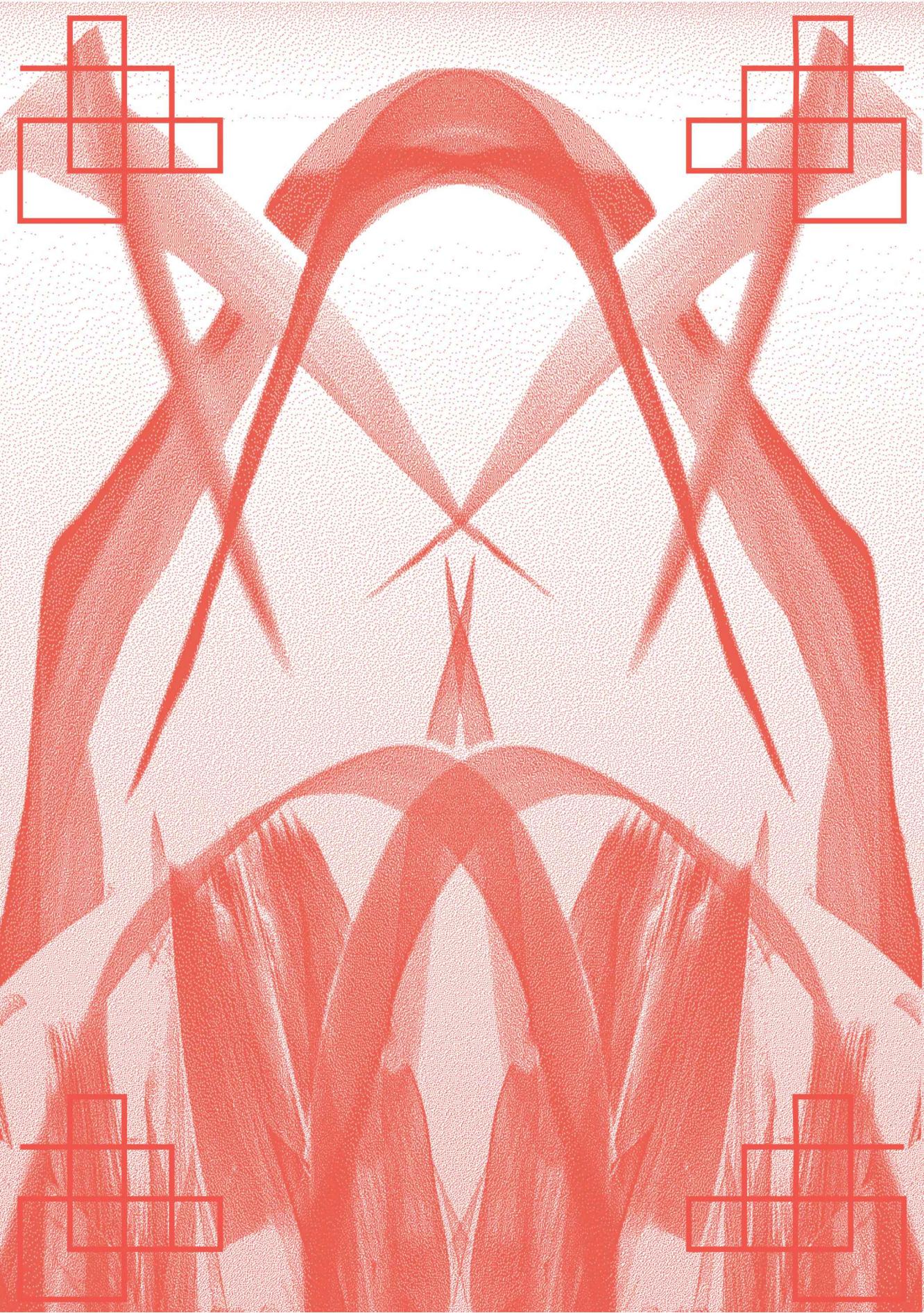
Technological innovation: promoting the integration of mechanization and agronomy and digitalization, supporting the equipment industry, and achieving high-quality development.

Institutional innovation: breaking through institutional obstacles and promoting the coordinated development of agricultural mechanization.

Policy innovation: strengthening joint policy innovation and supporting and guiding agricultural mechanization and agricultural machinery industry breakthroughs in key difficulties and challenges.



© Qingdao Hongzhu Agricultural Machinery Co., Ltd. Hongzhu V10



Chapter 6

Development focus and directions

This section discusses the development focus and future directions of sustainable agricultural mechanization in China, including prioritizing the development of whole-process mechanization of staple crop production; improving the mechanized production of cash crops; accelerating mechanization in hilly and mountainous areas; promoting the mechanization of livestock management and aquaculture; improving mechanization of the primary processing of agricultural products; and innovating the development of “mechanization + digitalization” and other aspects. Furthermore, this section summarizes the important role of international organizations in the development of sustainable mechanization and discusses the far-reaching significance of international cooperation and international experience for the future development of sustainable agricultural mechanization in China, especially for the agricultural machinery quality inspection system. These are of great significance to greening agricultural modernization.

6.1 PRIORITIZING THE DEVELOPMENT OF WHOLE-PROCESS MECHANIZATION OF MAIN CROP PRODUCTION

6.1.1 Making up for shortcomings in the whole-process mechanization of staple crop production in key regions

This involves focusing on weak links such as mechanized rice transplanting in the rice double-cropping area, particularly in conservation agriculture systems; mechanized harvesting of maize kernels; water-saving irrigation of wheat; mechanized planting and harvesting of potato and other root and tuber crops; no-tillage seeding of soybean in conservation agriculture systems; and integration and matching of agricultural machinery, agronomy, and good varieties.

Demonstration and technical training will be strengthened. By 2025, the rice planting mechanization rate will reach 65 percent and the potato planting and harvesting mechanization rate will reach 45 percent. The aim is to accelerate the integration and matching of mechanization technologies with plant protection, primary processing in production areas, and straw management and other links with farming and harvesting, focusing on the mechanized production of maize in the hilly and mountainous areas in Southwest China and soybeans in South China. Several whole-process mechanization solutions should be summarized and promoted.

6.1.2 Building a green and efficient mechanized production technology system

The aim is to vigorously promote conservation agriculture, explore suitable soil management methods in the light of local conditions, improve the productivity of crop land through mechanization, and stabilize crop production. Another aim is to support the development of the seed industry, guide and accelerate the selection and breeding of crop varieties suitable for mechanized production, and carry out exchanges and demonstrations of mechanization technology and equipment for plant breeding and seed treatment. A further aim is to accelerate the application of whole-process mechanization for crop production and promote the establishment of regional, standardized, and mechanized production systems with high quality and high efficiency.

6.1.3 Promoting the mechanization of crop production to decrease losses and improve quality

The aim is to strengthen technical guidance for precision seeding and loss reduction of grain crops, improve mechanization operating standards and norms, develop the comprehensive capacity and competency of operators on standardized mechanization operations, and lead enterprises to actively improve the performance of seeding and harvesting machinery in conservation agriculture systems. The loss rate of mechanized harvesting of grain will be included in the terms of mechanization hire services. Farmers and machinery operators will be guided to realistically determine the working time and schedule, select the applicable machinery and equipment, and standardize operations so as to ensure the good performance and condition of the machinery and equipment, efficient operations, and effective loss reduction.

6.1.4 Strengthening the capacity and resilience of mechanization in disaster prevention and mitigation

The aim is to strengthen machinery maintenance guidance and the training of operators. It is essential to emphasize the need for precise management and coordination, timely release of information on supply and demand of hire services and strengthening of the connection between agricultural machinery operation progress and agricultural statistics. Relevant departments should particularly act upon meteorological warnings for cross-regional operations, transportation of operating machinery, and management of operation orders and emergency handling so as to ensure safe, stable, high-quality, and efficient mechanized production.

6.2 OPTIMIZING MECHANIZED PRODUCTION OF CASH CROPS

6.2.1 Improving mechanized production of main cash crops

The aim is to (1) focus on mechanization in key cash crop regions and weak production links; (2) promote mechanization technologies for equal-row planting and picking of cotton in the Yellow River Basin; (3) promote mechanization technologies for high-efficiency planting and low-loss harvesting of winter rapeseed in the Yangtze River Basin; (4) promote mechanization technologies for film-free planting and whole harvesting of summer peanuts in the main peanut production areas; (5) promote mechanized harvesting technologies in the main sugarcane production areas in South China; and (6) promote mechanization technologies for high-efficiency planting and rapid harvesting in the main sugar beet production areas. By 2025, the mechanization rate for cotton harvesting will reach 60 percent; the mechanization rates for peanut planting and harvesting will reach 65 percent and 55 percent, respectively; the mechanization rates for rapeseed planting and harvesting will reach 50 percent and 65 percent, respectively; and the mechanization rate for sugarcane harvesting will reach 30 percent. All these developments should be oriented towards sustainable cropping systems such as conservation agriculture, particularly in relation to the seeding and planting, as well as the harvesting of crops grown underground such as roots, tubers and peanuts.

6.2.2 Making breakthroughs in the mechanization of key production links of special cash crops

Regarding the open large-scale planting base of vegetables, the aim is to actively promote mechanized planting technology through using elements such as standardized seedling nursery care, precision seeding, efficient transplanting, and others. An additional aim is to promote the demonstration and application of mechanized harvesting technologies for leafy and root vegetables and the picking auxiliary platform for flowering and fruiting type vegetables. Another objective is to promote suitable-for-mechanization transformation and standardized construction for orchards and tea plantations, along with promoting special machinery, equipment, and auxiliary platforms for ditching fertilization, weeding and spraying, water-saving irrigation, pruning and picking, and other operations in orchards and tea plantations. It is important to actively promote mechanized production in the large-scale planting bases of Chinese medicinal crops, tropical field crops, and in agroforestry systems and to promote experiments and demonstrations of high-efficiency and low-loss mechanized harvesting technology for cereals and legumes. By 2025, the mechanization level for planting and harvesting of major vegetable varieties will reach 30 percent and the mechanization level for field management in orchards and tea plantations will reach 35 percent.

6.2.3 Promoting the mechanization development of protected agriculture

Standardized greenhouse facilities suitable for mechanized production should be actively promoted in the main regions of protected agriculture (e.g. in facility agriculture and greenhouses). The aim is to (1) promote the standardization of protected agriculture with energy-saving construction materials and low-power electronic devices; (2) focus on the shortcomings in mechanization technology and equipment for precision seeding, nursery plant care, grafting, transplanting, and harvesting; (3) promote the technology and equipment for land levelling, fertigation and microirrigation, electric transportation, and multifunctional

operation platforms; (4) improve the digitalization of protected agriculture; (5) actively promote intelligent facilities and mechanization technologies such as automatic environmental regulation, automatic fertigation, and digital monitoring of crop growth; and (6) explore the demonstration and application of agricultural robotics for activities such as grafting, pollination, inspection and harvesting.

6.3 ACCELERATING MECHANIZATION IN HILLY MANAGEMENT AND MOUNTAINOUS AREAS

6.3.1 Speeding up R&D, extension, and the application of suitable agricultural machinery and equipment in hilly and mountainous areas

The aim is to (1) actively develop high-efficiency specialized machinery for agricultural production in hilly and mountainous areas; (2) promote R&D into general machinery for hilly and mountainous areas as well as into the high-efficiency and specialized machinery needed for the development of special agricultural products; (3) increase R&D into small-sized machinery suitable for production in hilly and mountainous areas; and (4) promote the integration of production, education, research and extension, and accelerate the extension and application of agricultural machinery and technology suitable for hilly and mountainous areas.

6.3.2 Promoting the suitable-for-mechanization transformation of farmland in hilly and mountainous areas

The aim is to build a standard framework for the suitable-for-mechanization transformation of farmland in hilly and mountainous areas. Depending on the geological characteristics, the different cropping systems and the hilliness of the terrain, the goal is to improve the evaluation standard for suitable-for-mechanization transformation of farmland, clarify the requirements for infrastructure and operating conditions in fields and on field tracks, and design solutions suitable for different terrain characteristics to effectively improve transportation and operating conditions for agricultural machinery while striking a balance with the environmental sustainability and integrity of the landscape.

6.3.3 Promoting institutional innovations in agricultural production and management

The aim is to actively develop innovative business models for hire services such as “new business entity + appropriate scale + whole-process mechanization + integrated agricultural service centres”, “new business entity + appropriate scale + ICT-based mechanization hire services”, and “new business entity + large-scale operations + industries with distinctive advantages + full-process mechanization”.

Additional aims are to (1) accelerate the integration of mechanization with agronomy and digitalization in production and service mechanisms; (2) promote suitability for mechanization from all angles, including variety, cultivation system, breeding method, production scale and post-harvest processing (it is important to match good-quality machinery with good varieties, methods, farmland and institutions); (3) build the service and extension mechanism in line with the development of public welfare and business interests; (4) develop the capacity of mechanization technology extension in hilly and mountainous areas; and (5) guide diverse social forces to actively participate in public-welfare technology extension.

6.4 PROMOTING THE MECHANIZATION OF LIVESTOCK AND AQUACULTURE

6.4.1 Promoting the whole-process mechanization of large-scale livestock and poultry management

The aims are to (1) optimize the technical standard system for mechanization of animal husbandry; (2) formulate technical specifications for equipment in large-scale breeding facilities for the major livestock breeds such as pigs, laying hens, broilers, dairy cows, beef cattle and sheep; (3) strengthen the integration of livestock and poultry varieties, and breeding technology, as well as the facilities and mechanical equipment used; (4) support small- and medium-sized farms (households) to improve facilities and equipment, and promote whole-process mechanization in animal production; (5) accelerate the application of advanced and applicable mechanization technology and equipment such as for incubation and breeding; epidemic prevention systems; intelligent feeding; accurate environmental control; animal behaviour monitoring; collection, storage, and processing of livestock products; and resource use of manure; and (6) establish regional, large-scale, standardized, and informationized mechanization modes for livestock and poultry production. Additionally, it is important to provide mechanization solutions for the prevention and control of animal and zoonotic diseases (e.g. African swine fever and COVID-19) in livestock farms (CSAM, 2020b), and it is crucial to optimize the integration of mechanization into One Health approaches.

6.4.2 Establishing the whole-process mechanization system for the green development of aquaculture and fisheries

The aims are to (1) promote the use of facilities and equipment adapted to the green development of aquaculture; (2) strengthen the integration of aquaculture varieties, technologies, facilities and mechanical equipment; (3) accelerate the development of related mechanization technology and equipment for feeding, oxygenation, cleaning, delivering vaccine injections, harvesting, sorting and grading, storage, water quality monitoring, aquatic grass management, water treatment, and other aspects; and (4) optimize the standard system for mechanization of aquaculture. A batch of standardized whole-process mechanization solutions will be summarized.

6.4.3 Promoting green technologies and equipment for animal production and nutrient recycling

The aims are to (1) accelerate the extension and application of mechanization technologies such as high-quality forage grass silage, use of crop straw as feed, and resource use of livestock and poultry manure as fertilizer; (2) promote agroecological approaches for mixed farming systems and circular agriculture models; (3) promote innovations in the experiential and participatory extension of new equipment and technologies for livestock, poultry, aquaculture and fisheries; (4) select and promote green and novel technologies, equipment, processes, and models for the mechanization of animal production; (5) accelerate the elimination of old types of machinery and equipment with high energy consumption, high pollution and poor safety performance to reduce injuries to people and minimize the adverse impacts of hazardous chemicals on human health and environment; and (6) promote the upgrading of technology and equipment and promote energy-saving machines and equipment for livestock, poultry, aquaculture and fisheries.

6.5 PROMOTING THE MECHANIZATION OF STORAGE AND PROCESSING

6.5.1 Improving the mechanization level of storage and primary processing of agricultural products

In the storage and primary processing of grain and rapeseeds, the aim is to focus on the development of low-carbon and clean energy technologies (e.g. air energy and solar energy) in areas such as drying, mechanical ventilation and storage, integrated drying and storage facilities, and low-temperature pressing. In the storage and primary processing of fresh agricultural products (e.g. fruits and vegetables, livestock, poultry and aquatic products), it is important to focus on the development of storage facilities and commercial treatments such as pre-cooling, preservation, freezing, classification, grading, segmentation and packaging. Technological innovations should be strengthened to focus on weak links and deficient areas of storage and primary processing to promote R&D, manufacturing, extension, and application of key technologies and equipment such as energy-efficient and environmentally friendly drying of grain and rapeseeds, green technologies for grain storage, low-temperature pressing, cleaning, and grading of fruits and vegetables, and cold-chain logistics.

6.5.2 Promoting the integrated application of mechanization technology for the primary processing of agricultural products

Additionally, it is important to focus on improving quality, decreasing losses, and increasing the efficiency of agricultural products; promoting green storage technologies for grain storage facilities and cold-chain logistics facilities for fresh fruits and vegetables; and promoting green and energy-saving classified processing of agricultural products. It is essential to carry out R&D, screening, evaluation, and engineering integration of technical facilities and equipment, and establish the mechanization technology system of primary processing of agricultural products. It is also necessary to establish technical models of storage and primary processing based on regions, industries and scales, and formulate standards and procedures for storage and primary processing.

6.6 DEVELOPMENT OF “MECHANIZATION + DIGITALIZATION” INNOVATIONS

6.6.1 Promoting technological innovation of intelligent agricultural machinery and equipment

It is crucial to promote the rapid development of precision agriculture and smart agriculture technologies, including machinery navigation and display systems, operation management systems, and remote data communication management systems. The aim is to accelerate tackling key technologies such as machinery operation sensors, intelligent network terminals, and big data platforms for machinery operations; promote the digitalization of machinery operation monitoring; develop the technology of precision land levelling, precision seeding, precision fertilization, controlled traffic systems, and precision pesticide application technologies, and develop intelligent machinery and equipment for the precise control of seed, fertilizer and pesticides; and promote the integrated application of technologies used in agricultural machinery and equipment such as Beidou automatic navigation, ISOBUS (ISO, 11783), high-pressure common rail, power shifting, electromechanical and hydraulic integration, and electromagnetic pulse valves for sprayer nozzles.

6.6.2 Demonstrating intelligent technology application

The aims are to (1) deepen the extension and application of the Beidou system in agricultural machinery and equipment, promote novel and intelligent machinery and equipment, and promote the development of smart agriculture and digital village construction; (2) actively guide the application of high-end intelligent machinery and equipment into agricultural production and comprehensively improve the operation quality and efficiency of machinery and equipment in the whole process of land preparation, planting, managing and harvesting; (3) promote the application of autonomous driving, remote monitoring, and intelligent control technologies based on Beidou and 5G technologies in large tractors, combine harvesters, rice transplanters, and others; (4) promote the wide application of intelligent equipment in precision agricultural production (e.g. precision seeding, fertilization, pesticide application and harvesting); and (5) accelerate the application of intelligent equipment in facility horticulture, livestock, poultry, aquaculture and fisheries, and primary processing of agricultural products.

6.6.3 Promoting digital management of mechanized production

The aims are to (1) accelerate the construction of the internet of things for mechanized production and promote the integrated development of intelligent agricultural machinery and smart agriculture; (2) promote the application of mobile apps, face recognition, QR code management of subsidized machinery and equipment, internet of things monitoring, and other technologies to realize the online handling of machinery purchase subsidies, testing and identification; (3) promote the integrated development of “mechanization + digitalization”; and (4) accelerate the digitalization transformation of mechanization industry management, machinery operation monitoring, as well as the supply and demand connection of mechanization hire services.

6.7 STRENGTHENING INTERNATIONAL COOPERATION AND LEARNING FROM INTERNATIONAL EXPERIENCE

6.7.1 The Centre for Sustainable Agricultural Mechanization (CSAM) of the Economic and Social Commission for Asia and the Pacific (ESCAP)

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) hosted in Beijing, China. The Centre's mandate is to work with the 62 ESCAP member states and associate members and other relevant stakeholders to promote sustainable agricultural mechanization for food security, improved rural livelihoods and sustainable development of agriculture across the Asia-Pacific region, thereby contributing to the attainment of the Sustainable Development Goals (SDGs). CSAM has been assisting member states in implementing solutions in three areas, namely strengthening regional cooperation and networks, enhancing capacities, and undertaking research and analytical work. South-South and Triangular Cooperation is an important cornerstone of the programmatic work of CSAM.

CSAM is providing a platform to share knowledge and experience amongst all ESCAP member states, including exchange of China's knowledge and experience with other countries as well as good practices and learnings from other countries with China. The centre has close cooperation in the field of sustainable agricultural mechanization with departments and entities of MARA such as the International Cooperation Department, the Agricultural Mechanization Department, the General Station of Agricultural Machinery Testing and Appraisal,

the General Station of Agricultural Mechanization Technology Development and Extension, and Nanjing Institute of Agricultural Mechanization.

China hosted CSAM's annual flagship event, the Regional Forum on Sustainable Agricultural Mechanization in Asia and the Pacific, in 2013 (Qingdao) and 2018 (Wuhan), and has actively participated in CSAM's *Asian and Pacific Network for Testing of Agricultural Machinery* (ANTAM) initiative which aims to promote harmonization of testing standards of agricultural machinery amongst participating countries in the Asia-Pacific region in order to enhance the quality, performance, occupational safety and environmental dimensions of the machinery as well as to support more integrated trade in agricultural machinery (CSAM, 2020a). ANTAM works in collaboration with international and regional organizations, including the Italian National Agricultural Machinery Agency (ENAMA) and the European Testing Network of Agricultural Machinery (ENTAM), FAO, the Organisation for Economic Co-operation and Development (OECD), and the United Nations Industrial Development Organization (UNIDO). Another CSAM-facilitated network titled the Regional Council of Agricultural Machinery Associations in Asia and the Pacific (ReCAMA) has benefited from the participation of the China Agricultural Machinery Distribution Association, the China Agricultural Mechanization Association, and the China Association of Agricultural Machinery Manufacturers, and a number of training and study tours. CSAM is also collaborating with China Agricultural University to implement a pilot initiative on mechanization-based solutions (including conservation agriculture) for integrated management of straw residue being implemented in Laixi, Shandong province. Since 2020, CSAM has joined hands with the Administrative Committee of Yangling Agricultural High-Tech Industry Demonstration Zone of China to organize technical training on climate-smart mechanization for countries in Central Asia as well as other subregions.

In the future, CSAM will continue to serve as a regional knowledge hub on sustainable agricultural mechanization and work closely with China and other member states for promoting knowledge exchange, technical cooperation and capacity development in support of the relevant Sustainable Development Goals.

6.7.2 Project financed by the World Bank: Guangdong agricultural non-point source pollution control

Agricultural non-point source pollution refers to the pollution of water, soil, air and agricultural products caused by pollutants produced as a result of improper disposal during the process of agricultural production and living activities in rural areas, mainly including chemical fertilizer, pesticides and livestock and poultry excrement. Agricultural non-point source pollution is one of the main factors harming the rural ecological environment and it seriously restricts the sustainable development of agriculture and rural areas.

In the *Guangdong Agricultural Non-Point Source Pollution Control Project Loaned by the World Bank* (Guangdong, 2021), there is a topic on *Policy Research on Agricultural Non-Point Source Pollution Control in Guangdong (Environment-Friendly Planting Industry Project)*. It mainly includes the technology extension, research, and policy suggestions for environmentally friendly plant production, such as conservation agriculture, decreasing fertilizer and pesticide application, and precision fertigation.

The aspects of conservation agriculture principally studied by the project were direct-seeding technology for rice, conservation agriculture for the sweet maize production system, and related agricultural machinery and equipment demonstrations. The results show that mechanized conservation agriculture can significantly increase profits and significantly decrease fertilizer

application without diminishing yield. The results and experiences of the project should be further promoted in appropriate regions within China as well as in other developing countries.

6.7.3 The Food and Agriculture Organization of the United Nations (FAO) and the framework of sustainable agricultural mechanization

Currently, millions of smallholders and family farmers around the world still rely on human labour. In sub-Saharan Africa and Asia, where agricultural production is largely dependent on smallholders, agricultural mechanization inputs are urgently needed to promote sustainable production, improve livelihoods, and create new business opportunities and decent jobs for women and youth. Sustainable agricultural mechanization is an important pillar for achieving Sustainable Development Goals 1, 2, 5, 12, and 13 of the 2030 Agenda for Sustainable Development.

FAO has been dedicated to promoting sustainable agricultural mechanization globally through agricultural development and investment programmes. FAO advocates for sustainable agricultural mechanization, digitalization and technological innovations which significantly enhance the sustainability and resilience of agrifood systems and contribute to the global response to COVID-19 and the recovery of agricultural production.

FAO and its partners have formulated regional strategies, including A Regional Strategy for Sustainable Agricultural Mechanization in Asia and the Pacific (Mrema, Soni and Rolle, 2014) and the Framework for Sustainable Agricultural Mechanization in Africa (FAO and AUC, 2018). From 2020 to 2021, a series of webinars on the implementation of the framework for sustainable agricultural mechanization in Africa were jointly organized by FAO, the African Union, and the African Conservation Tillage Network. In the promotion of agricultural mechanization hire services, FAO and the International Maize and Wheat Improvement Center (CIMMYT, its Spanish acronym) have jointly published a training manual, *Hire Services as a Business Enterprise* (Sims et al., 2018) for small agricultural mechanization service organizations, aiming to train potential mechanization service providers, including individuals, cooperatives, farmer organizations, and small- and medium-sized enterprises. FAO and CIMMYT have converted the training manual into online training courses at the FAO elearning Academy (FAO, 2022c). In 2021, FAO and the International Telecommunication Union (ITU) jointly organized a webinar on *Agricultural robotics for climate-resilient food production* in the AI for Good webinar series to discuss the current state of agri-robot development globally, including emerging applications in remote sensing, data collection, localization, navigation and computing capabilities (ITU, 2021). The FAO publication *Empowering women farmers – A mechanization catalogue for practitioners* (Justice, Flores Rojas and Basnyat, 2022) introduces three ways in which sustainable mechanization can empower women and respond to their needs, including women as customers of mechanization service providers, operators of machinery and equipment or staff of a mechanization hiring services business, and entrepreneurs managing their own mechanization hiring services agribusiness. Additionally, the FAO-IFPRI study *Agricultural mechanization and child labour in developing countries* (Takeshima and Vos, 2022) focuses on the use of tractors, which are among the most versatile of farm mechanization tools and are universal power sources for all other driven implements and equipment in agriculture, with significant potential to replace animal draught power and human power, including the muscle power of children.

The FAO Sustainable Agricultural Mechanization website (FAO, 2022a) provides comprehensive information and knowledge on sustainable agricultural mechanization, global case studies, business models for hire services, and databases of agricultural machinery equipment and manufacturers. It also combines with sustainable agricultural technologies such as conservation agriculture and climate-smart agriculture. The FAO Global Sustainable Agriculture Mechanization Community of Practice (SAM – CoP) (FAO, 2021a) provides an online platform for global sharing of experiences and technical networking, with mutual concern about sustainable agricultural mechanization suitable for smallholders and small- and medium-sized enterprises (SMEs).

Moreover, in 2021 FAO launched the *Global Action on Green Development of Special Agricultural Products: One Country One Priority Product* (OCOP) (FAO, 2021b). This Global Action aims to develop green and sustainable value chains for special agricultural products, support small and family farmers reap the full benefits of a global market, help the transformation of current agrifood systems, and ultimately support countries to the achievement of the Sustainable Development Goals. In this regard, sustainable agricultural mechanization is considered as one of the green practices and technologies for the green development in plant production under OCOP. For future development, China will continue contributing to achieving the Sustainable Development Goals, strengthening technological innovations in sustainable agricultural mechanization and digitalization development, enhancing the sustainability and resilience of the agrifood system, and sharing the experiences of China's response to COVID-19 and recovery of agricultural production.

6.7.4 European Green Deal and sustainable agricultural mechanization

FAO is collaborating with the European conservation agriculture Federation (ECAF) to promote mechanized conservation agriculture. ECAF is a non-profit international association that promotes conservation agriculture technologies for the preservation of agricultural soils and biodiversity in the context of sustainable agriculture. It includes 19 European national associations that promote best practices in conservation agriculture technologies in Europe. In 2021, with support from FAO, ECAF, and SWISS NO-TILL, it organized the Eighth World Congress on Conservation Agriculture.

FAO has formed a partnership with the European Agricultural Machinery Association (CEMA), an international non-profit organization, to promote the wider use of sustainable agricultural mechanization in developing countries. CEMA represents the European association of the agricultural machinery industry and includes 11 national members. Its network includes large multinational companies as well as numerous SMEs in Europe. The 2021 CEMA Summit *Seeding the Future of Sustainable Farming – Advanced Farm Machines & Solutions to Deliver on the European Green Deal* (CEMA, 2021) discussed how the European Union can assist farm technology uptake and achieve a more digital and greener agriculture for producers of all sectors and sizes. Digital agriculture, modern agricultural machinery, agricultural data management systems, and agricultural robotic solutions will help European agriculture meet the dual challenges of producing quality food while preserving nature and biodiversity. Promoting technological innovations and moving toward digital transformation in the agrifood sector require a strong Common Agricultural Policy (CAP). According to CEMA, supporting farmers in the adoption of precision agriculture and digital technologies has become an important priority for the agricultural sector and society in order to achieve the objectives of the European Green Deal (European Commission, 2021). A CAP that supports sustained investment in advanced

agricultural machinery and technologies will ensure a smarter, greener and more competitive future for European agriculture.

6.7.5 Optimizing the machinery testing and emission standard system in China: learning from international experience

In order to implement the *Law on Environmental Protection of the People's Republic of China* and the *Law on Atmospheric Pollution Prevention and Control of the People's Republic of China*, and to prevent and control air pollution from diesel vehicles, gasoline vehicles and nonroad mobile diesel machinery, the Ministry of Ecology and Environment and the State Administration of Market Supervision jointly issued three national pollutant emission standards: *Diesel Vehicle Pollutant Emission Limits and Measurement Methods (Free Acceleration Method and Loading Deceleration Method)*; *Gasoline Vehicle Pollutant Emission Limits and Measurement Methods (Dual Idle Speed Method and Simple Method Working Condition Method)*; and *Diesel Mobile Nonroad Machinery Exhaust Smoke Limits and Measurement Methods*. In order to carry out the local implementation of the *Law on Atmospheric Pollution Prevention and Control of the People's Republic of China* on the prohibition of the use of high-emission mobile nonroad machinery, the standards set different emission limits according to the emission stage of diesel mobile nonroad machinery. Additionally, the standards formulated more stringent emission limits according to the requirements in low-emission control areas. These standards have been formally implemented since 1 December 2018.

The emission standards of agricultural machinery engines in China will be upgraded from Stage III to Stage IV and the main reference is the European standard. The European standard mainly adopts the selective catalytic reduction (SCR) technical route, which has the advantage of decreasing fuel consumption and improving fuel effectiveness and economy. China's agricultural machinery emissions are still high. Among nonroad machinery emissions, hydrocarbon (HC) emissions of agricultural machinery accounted for 47 percent, nitrogen oxide (NO_x) emissions of agricultural machinery accounted for 34 percent, and particulate matter (PM) emissions of agricultural machinery accounted for 38 percent. The emission standard Stage IV in China is equivalent to the European Union Stage IIIB standards, but even more stringent. It is in line with China's goal to develop new types of green and efficient machinery and promote high-quality and efficient agricultural development.

6.7.6 Summary

The development path and experiences of agricultural mechanization in China are of great reference value to developing countries and regions. In the future, international cooperation should be strengthened. Through South-South Cooperation and the Belt and Road Initiative, sharing experiences and technology of sustainable agricultural mechanization in China, establishing an international information exchange mechanism, strengthening China's cooperation with international organizations to implement international mechanization demonstration projects, and contributing Chinese experiences and technology to global green agricultural transformation and modernization will all be important.







Chapter 7

Investment and policy recommendations

This section puts forward a series of policy recommendations for the development of sustainable agricultural mechanization in China, including increasing financial support and investment, promoting technological innovation of agricultural mechanization, strengthening the modernization of agricultural mechanization and machinery management services, promoting innovation of the agricultural mechanization extension service system, strengthening the industrial cluster, industrial chain and agricultural mechanization hire services, developing the capacity of human resources for sustainable agricultural mechanization, and enhancing international cooperation and exchanges.

7.1 INCREASING FINANCIAL SUPPORT AND INVESTMENT

The aims are to (1) consistently implement policies for agricultural machinery purchase subsidies; (2) focus on supporting weak links in mechanization, application, and extension of green, efficient and intelligent machinery as well as IT equipment; (3) explore subsidy pilots for purchasing innovative machinery products, scale up comprehensive subsidy pilots for machinery purchases, and promote the replacement of scrapped agricultural machinery; (4) vigorously implement major projects such as subsidies for mechanized subsoiling in land preparation and the *Action Plan for Conservation Agriculture of Black Soil in Northeast China (2020–2025)*; (5) promote the suitable-for-mechanization transformation of farmland; (6) promote innovative financial and insurance services for agricultural machinery; (7) increase the scale of credit guarantees; (8) implement discount interest rates on loans; and (9) launch pilot programmes for comprehensive agricultural machinery insurance.

Recommended investment direction for sustainable agricultural mechanization in China:

- invest in strengthening infrastructure construction for mechanization, including road networks, the suitable-for-mechanization transformation of farmland in hilly and mountainous areas, water-saving irrigation systems, rural electrification with renewable energy, information service base stations, ICT tools and digitalization transformation of agricultural machinery, and simple and user-friendly interface digital service platforms (also suitable for users who cannot recognize Chinese characters);
- invest in the transformation of scientific and technological achievements in agricultural machinery;
- invest in strengthening the quality testing standards and extension of agricultural machinery;
- invest in capacity development to improve the comprehensive enterprise operation capabilities and knowledge skills of entrepreneurs and farmers operating agricultural machinery services;
- invest in awareness raising of different stakeholders: support the development of new agricultural operation and service entities such as farmers' cooperatives and family farms; attract major labour forces to return to homelands and participate in agriculture; attract young entrepreneurs to start a business related to agriculture; strengthen rural women's capacity development; and promote women-friendly agricultural mechanization;
- optimize financial services and improve the subsidy system and enabling policies to achieve a win-win situation for farmers and hire service organizations;
- increase the analysis guidance and risk assessment of the mechanization hire service market, provide good enterprise development direction and industry standards and norms, and summarize key experiences and lessons;
- strengthen public-private partnership and promote cooperation between government, scientific research institutions, agricultural mechanization cooperatives, and leading enterprises to improve the service for small farmers; promote green and modern agriculture; and enhance the sustainability and resilience of agriculture; and
- strengthen international technology exchanges and cooperation and share China's experiences and technology to contribute to global sustainable agricultural mechanization through South-South and Triangular Cooperation, and other mechanisms.

7.2 PROMOTING TECHNOLOGICAL INNOVATIONS OF AGRICULTURAL MECHANIZATION

7.2.1 Strengthening overall coordination

The aims are to (1) strengthen the demand-side guidance for mechanization development and innovation and formulate a catalogue of demand for agricultural mechanization technology and equipment, and (2) guide research institutes and enterprises to focus on strengthening the missing links or weak links of agricultural machinery.

7.2.2 Optimizing the innovation system

The aims are to strengthen the construction of research bases for whole-process mechanization; promote the in-depth integration of production, education and research for agricultural machinery; and improve the R&D capabilities of core

technologies and equipment. It is necessary to establish innovation centres for agricultural machinery manufacturing. It is also important to establish a market-oriented mechanism for selecting innovation directions and a risk-sharing and benefit-sharing mechanism to encourage innovations in agricultural mechanization.

7.2.3 Strengthening the construction of interdisciplinary and multidepartmental joint platforms for technology innovation promotion and application

It is crucial to implement the integration of mechanization and agronomy as well as the integration of mechanization with digitalization and informatics. It is also critical to accelerate the adaptation of the mechanization hire service model to moderate-scale agricultural operations and the adaptation of mechanized production to farmland construction. The aim is to promote the transformation of scientific and technological achievements of agricultural mechanization through technological innovation, institutional innovation and policy innovation.

7.2.4 Increasing fiscal and taxation support

The aim is to support the R&D of key generic technologies for machinery and equipment and intelligent manufacturing, and implement preferential tax policies so that enterprises that purchase and use major technical equipment will benefit from the preferential policies for income tax. Imported parts and raw materials for agricultural machinery and equipment will benefit from import tax preferences.

7.2.5 Innovative financial support methods

The aim is to establish a diversified investment and financing system for modern design and manufacturing of agricultural machinery and equipment, encourage the establishment of various market-oriented development funds, and encourage social capital to invest in the fields of modern machinery design and manufacturing.

7.3 STRENGTHENING THE MODERNIZATION OF AGRICULTURAL MECHANIZATION AND MACHINERY MANAGEMENT SERVICES

The aim is to establish a government-led platform for national agricultural machinery management and service and promote innovations in the aspects of strengthening the application of an intelligent monitoring terminal for agricultural machinery, establishing and improving the agricultural machinery management services and financial guarantee mechanisms, and others.

7.3.1 Establishing a national management and service platform of agricultural machinery led by government

The aim is to establish a national management and service platform for agricultural machinery led by MARA. This platform will coordinate the modernization development of machinery management and service. The platform should have the multiple functions of data query, online analysis, sharing and communication, and meet the needs of large-scale specialized households, agricultural cooperatives, leading enterprises, as well as smallholders. The platform should integrate agricultural machinery data from the government, enterprises, professional institutions, and other channels. Moreover, the subplatforms of agricultural machinery data analysis, remote monitoring of mechanization operations, machinery supervision, hire services, machinery markets and other aspects will be established to guide the transformation of agricultural machinery management and service toward modernization.

7.3.2 Promoting the application of intelligent monitoring terminals for agricultural machinery

The aim is to strengthen the extension and application of an intelligent agricultural machinery monitoring terminal in order to provide reliable, complete and continuous data for the agricultural machinery operation and maintenance management platform, and encourage enterprises, universities and research institutes to cooperate and jointly develop intelligent agricultural machinery testing terminals and systems. It is also essential to promote the practical application of intelligent testing terminals for machinery through policy guidance.

7.3.3 Establishing and optimizing financial guarantee mechanisms for agricultural machinery management and service

Financing of leasing and credit guarantee services for agricultural machinery should be provided to agricultural cooperatives, mechanization hire service enterprises, and family farms. In the form of government purchase services, green and environmentally friendly mechanization hire services will be provided for smallholders, such as for straw returning, subsoiling and land preparation, plastic film mulching and recycling systems, and for UAVs for plant protection, so as to enhance linkages between smallholders and modern agricultural development. In addition, it is important to promote innovation in areas such as agricultural credit guarantee mechanisms, credit cooperation between farmers' cooperatives, direct investment and financing services related to agriculture and agricultural machinery insurance.

7.4 PROMOTING INNOVATIONS OF THE AGRICULTURAL MECHANIZATION EXTENSION SERVICE SYSTEM

7.4.1 Establishing regional promotion centres for modern agricultural machinery

It is important to build regional extension centres for modern agricultural machinery according to local conditions. Aiming at industrialization, several regional modern machinery extension centres should be established based in the main bodies of agricultural machinery extension departments and township extension stations, with institutional innovation as the accelerator. Several national-level regional machinery promotion platforms should be established to integrate the product innovation chain and extension of agricultural machinery, and to promote the coordinated development of agricultural machinery R&D, achievement transformation, industry incubation, financial support and other areas.

7.4.2 Establishing high-level experimental demonstration bases for the whole-process mechanization of staple crop production

High-level experimental and demonstration bases for whole-process mechanization production should be established for the nine staple crops: rice, maize, wheat, potato, cotton, rapeseed, peanut, soybean, and sugarcane. Experimental demonstration and extension should be enhanced for mechanization technologies in key links such as land preparation and no-till seeding/planting in conservation agriculture systems, plant protection (especially integrated pest management), soil and plant nutrient management, harvesting, drying, and straw and cover crop management. It is important to achieve standardized and specialized production, optimize appropriate technical routes and equipment, promote the integration of mechanized technologies, explore the mechanized

production models for different crops and regions, and build several high-level experimental demonstration bases for whole-process mechanization.

7.4.3 Appraisal and extension project on new agricultural machinery products and technologies

The aims are (1) to organize appraisers to attend training courses and workshops and continue promoting the development of professional standards, teaching materials, and an appraisal question bank to ensure the authority and accuracy of appraisals; (2) conduct seminars on extension and appraisal technology for the agricultural machinery industry and improve the technical level of the appraisal industry; and (3) increase publicity efforts for new products and technologies and actively use new media such as mobile apps and instant messaging software to enable users to obtain relevant information in a timely manner.

7.4.4 Establishing an online platform for agricultural mechanization technology promotion and service

It is important to promote the application of Internet+ and big data technology to provide information support for the service system for agricultural machinery promotion and agricultural machinery socialization. It is also important to establish and complete the unified, coordinated, efficient, safe and reliable platform for dynamic information monitoring and service of mechanization operations to collect and distribute timely information on operation supply and demand. The aim is to cultivate and standardize the market of agricultural mechanization hire services. The platform will provide better agricultural machinery operations and maintenance services for agricultural operation entities and solve the problems of poor communication and asymmetry in supply-demand information.

7.5 STRENGTHENING THE INDUSTRIAL CLUSTER, INDUSTRIAL CHAIN AND AGRICULTURAL HIRE SERVICES

7.5.1 Promoting the establishment of the agricultural mechanization industrial chain and supply chain, integrating R&D, manufacturing and extension

The aims are to (1) promote the development of agricultural mechanization hire services, machinery maintenance and spare parts supply, agricultural machinery skills training and other industries, and constantly expand the industrial cluster and industrial chain of agricultural mechanization; (2) develop the capacity of hire service providers such as agricultural mechanization service enterprises, cooperatives, and large-scale mechanized farms; (3) promote innovative service modes such as “internet of things + agricultural machinery operation”; (4) support agricultural machinery service organizations in providing trusteeship services for agricultural production and facilitate the integration of smallholders with modern agricultural development; and (5) actively develop agricultural machinery cross-regional operations.

7.5.2 Demonstration of agricultural mechanization hire service entities for improving service quality and efficiency

It is important to (1) prioritize support for selected agricultural machinery cooperatives with good basic conditions, scientific management, and standardized operations; (2) support 1000 agricultural machinery cooperatives nationwide as demonstration cooperatives; (3) create the “double-entity mode”

of agricultural production and service entities that not only carry out whole-process mechanization services for crop production but also conduct moderate-scale production and business operations through land circulation and transfer of land contracting and thus promote the extension and demonstration of advanced and applicable machinery and equipment; and (4) carry out quality and efficiency improvement projects for major mechanized agricultural farm households, mechanization cooperatives, family farms, machinery operation service organizations and other new service entities of agricultural machinery to further promote the whole-process mechanization of staple crop production.

7.6 STRENGTHENING HUMAN RESOURCES FOR SUSTAINABLE AGRICULTURAL MECHANIZATION

The aims are to complete the rotation training of mechanization administrative personnel at all levels within two to three years and build a high-competency leadership team for agricultural mechanization management; strengthen the independence and controllability of agricultural machinery R&D and manufacturing supply chain and industrial chain; and comprehensively cultivate the innovative, application-oriented, interdisciplinary, and leading research talent in the field of agricultural machinery. Every year, no fewer than 5 million agricultural machinery operators will be trained.

7.6.1 Establishing a comprehensive modern vocational education system for agricultural machinery and equipment

It is recommended that the government attach more importance to modern vocational education in the field of agricultural machinery and equipment. It is necessary to strengthen the construction of a modern vocational education system for agricultural machinery and equipment and solve the challenges related to vocational education and personnel training. This could be led by MARA or the Ministry of Education, with participation from the Ministry of Science and Technology and the cooperation of multiple stakeholders. It is essential to implement financial investment in vocational education on agricultural machinery, expand the enrolment scale, increase the appropriation amount per student, implement the policy of free tuition, and increase financial support.

7.6.2 Strengthening support from local governments for secondary and higher vocational colleges

Local governments should strengthen financial support for higher vocational colleges related to agricultural machinery and equipment, improve the basic conditions, and provide precise assistance. They should fully understand that the increase in requests for the quantity and quality of teachers in related higher vocational colleges has arisen as a direct result of upgrading the agricultural machinery industry. Local government should promote the integration of agricultural production and education into local economic and social development plans while simultaneously planning relevant policies, measures, supporting methods, implementation approaches, and major projects for the integration of elements related to mechanization, such as production, industry and education.

7.6.3 Encouraging cooperation between industry and academia to prepare personnel in agricultural machinery and equipment

The aim is to improve the comprehensive training system for highly skilled mechanization personnel. The training system should be led by enterprises and based in the vocational colleges to deliver a blend of school education with enterprise training, with government providing promotion and social support.

According to the needs of enterprises, targeted training plans should be made to meet market demand. The government should formulate relevant supporting policies.

7.6.4 Strengthening the training of grassroots agricultural machinery and equipment personnel and practical talent

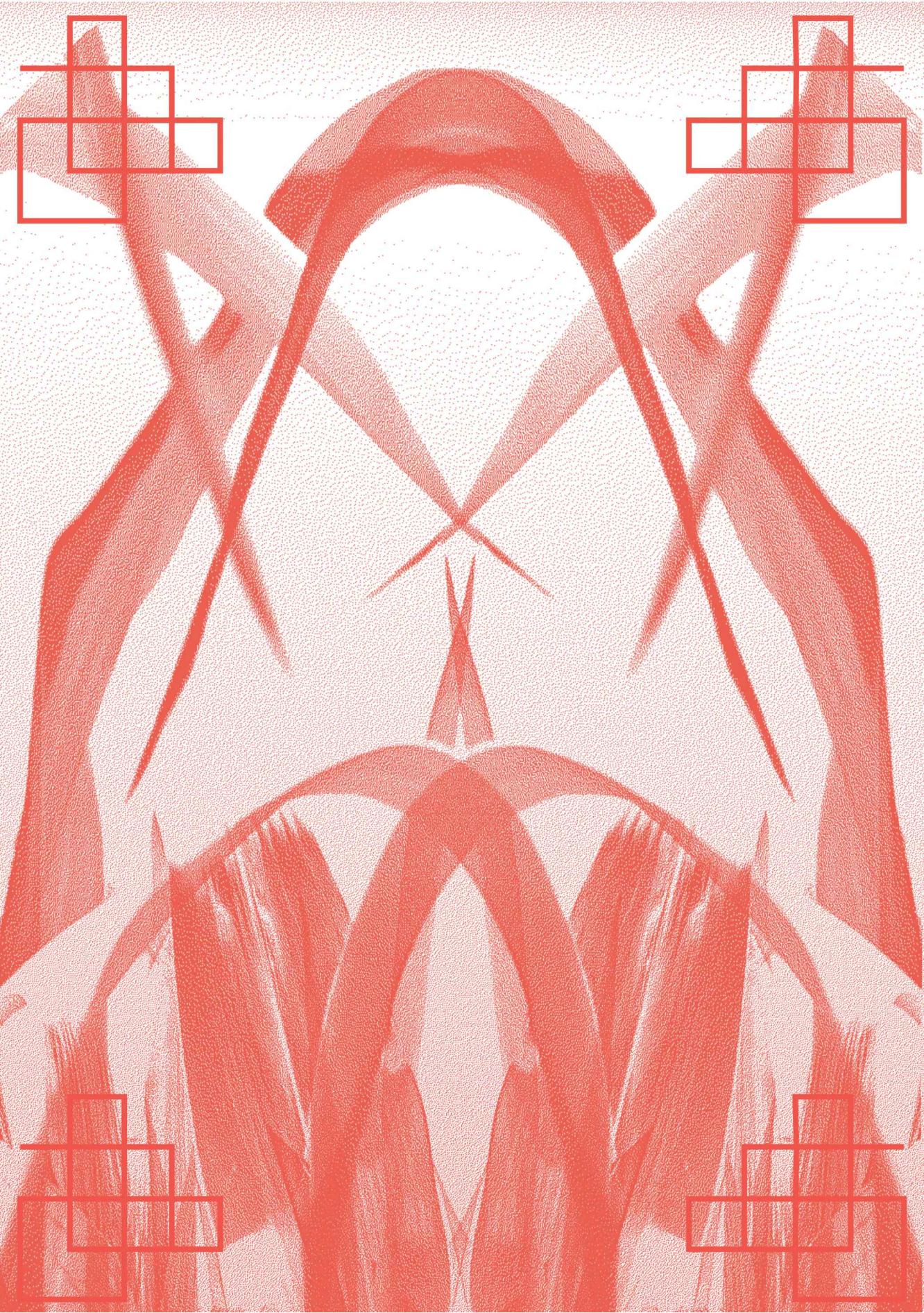
Led by MARA, jointly with the Ministry of Education (MOE), large-scale training in agricultural machinery equipment should be conducted for grassroots practical personnel. It is important to make full use of the main channels, including modern remote education networks in rural areas, the national culture and information resource-sharing project network, all kinds of farmers' education and training programmes, agricultural technology communication systems, and the range of vocational schools and training institutions. It is also important to integrate existing training projects, optimize the rural vocational education and training network, implement grassroots practical talent promotion projects in the modernization of agricultural machinery and equipment, and solve challenges in the training and capacity development of grassroots practical personnel and agricultural machinery personnel, including rural women, youth and vulnerable groups.

7.6.5 Empowering rural women and the vulnerable groups through sustainable mechanization

It is important to develop and promote smart, lightweight and user-friendly agricultural machinery and equipment that is suitable for rural women, the elderly and other vulnerable groups. More training on mechanized production should be conducted for rural women and the elderly labour force, so as to enhance the capacity development of rural women, create more good jobs and improve the livelihoods of rural women and vulnerable groups. As appropriate to local contexts, it is also important to apply a gender-responsive approach while promoting agricultural mechanization, so as to contribute to gender equality and improve working and living conditions for women and other vulnerable groups in rural areas.

7.7 DEEPENING INTERNATIONAL COOPERATION AND EXCHANGES

The aims are to (1) conduct extensive international exchanges and cooperation in the fields of advanced design technology, standardization of intelligent manufacturing, establishment of demonstration bases, human resources development, and constantly expanding cooperation areas; (2) support domestic and foreign enterprises and industrial organizations in carrying out technical exchanges and cooperation in modern design and manufacturing technology of agricultural machinery and equipment, and attract investment, technology and human resources; (3) encourage multinational companies and foreign R&D institutions to establish agricultural machinery manufacturing, R&D institutions, talent training centres, and demonstration factories in China; and (4) encourage domestic enterprises to participate in international mergers and acquisitions (M&A) and obtain shares in advanced foreign enterprises for machinery R&D and manufacturing.



Chapter 8

Business models and case studies of sustainable agricultural mechanization hire services in China

China's agricultural mechanization development and hire service (also called "socialized service" in China) business models have attracted more and more attention from developing countries. As mentioned in the previous sections, in recent years agricultural mechanization hire service organizations in China have been developing and expanding, and have shown diversified development patterns and enhanced public-private partnership. A large number of new agricultural business entities and service entities have emerged, including agricultural mechanization cooperatives, large-scale agricultural mechanized farms, SMEs and intermediary platforms based on ICT. This section discusses the current main business models and case studies of agricultural mechanization hire services in China.

8.1 BUSINESS MODELS OF SUSTAINABLE AGRICULTURAL MECHANIZATION HIRE SERVICES IN CHINA

The agricultural mechanization hire service is a concrete manifestation of agricultural mechanization. The upstream market of the hire service system includes the industrial manufacturing and circulation sectors of agricultural machinery and its parts, and the downstream market is mainly plant production and protection, animal husbandry, the fisheries sector, as well as storage and processing of agricultural products (Figure 15).

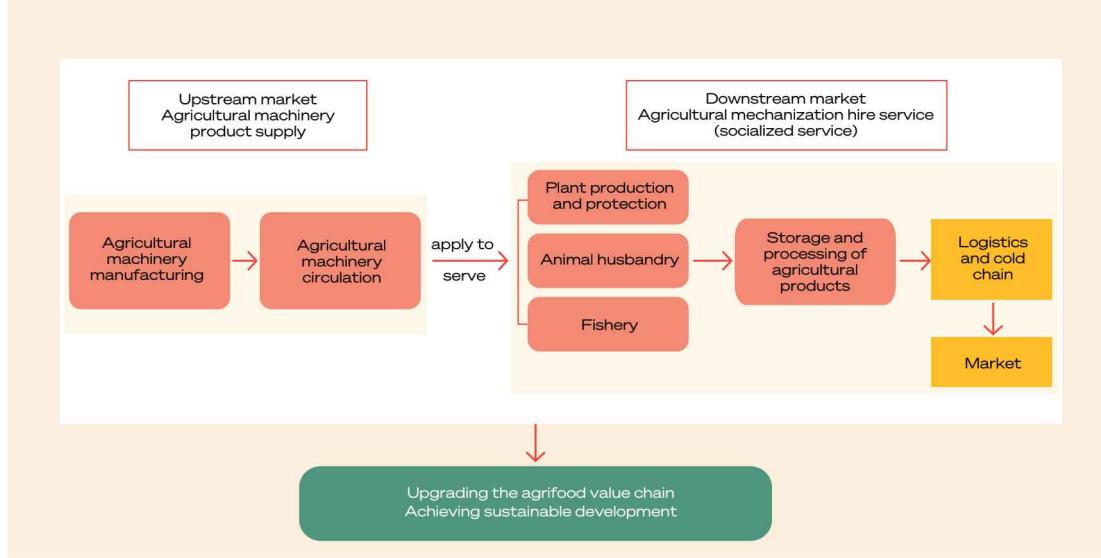


Figure 15
Upstream and downstream markets of agricultural mechanization hire service and its contributions

SOURCE: Authors' own elaboration.

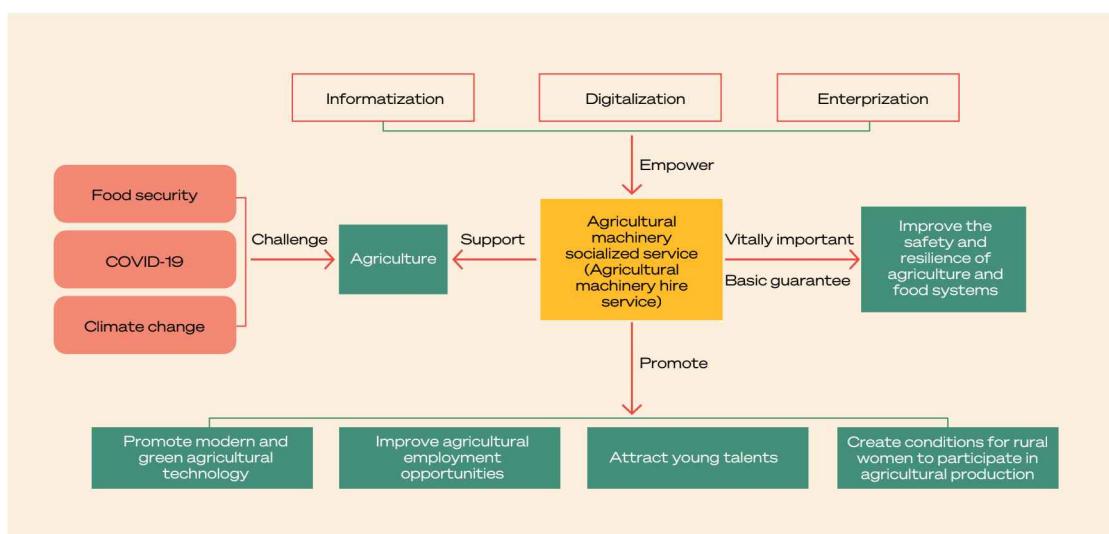


Figure 16
Agricultural mechanization hire service and its relationship with related factors

SOURCE: Authors' own elaboration.

The agricultural mechanization hire service in China has significantly contributed to improving the agrifood value chain and sustainable development. Facing many challenges (e.g. food security, the COVID-19 pandemic and climate change), it is essential to empower agricultural mechanization hire services with informatization, digitalization, and the capacity to create and run enterprises, and thus improve the sustainability and resilience of agrifood systems. Mechanization hire services are also important for promoting green and modern agricultural technologies,

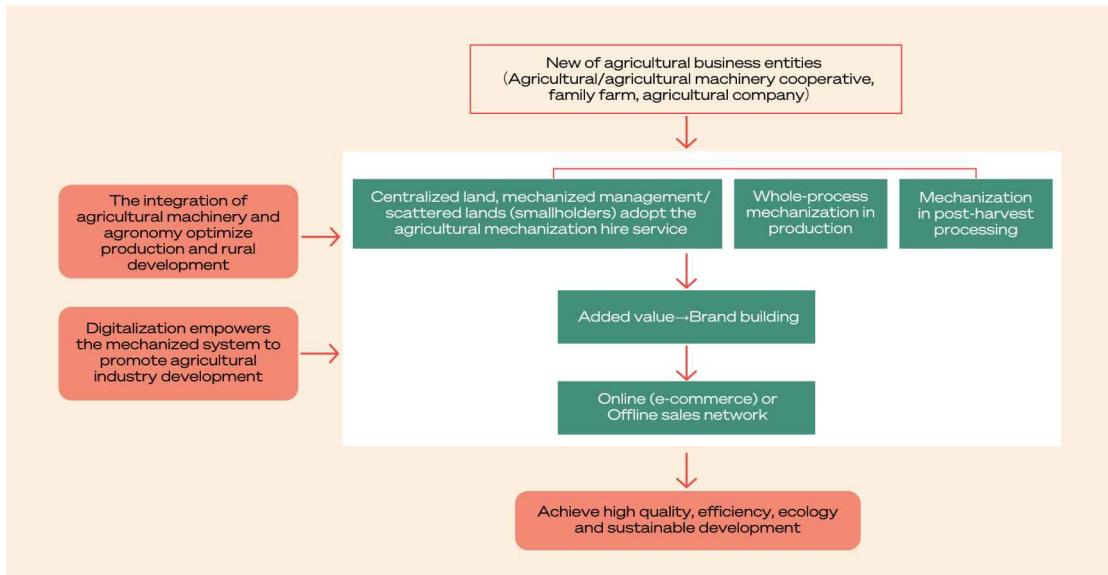


Figure 17
Agricultural mechanization hire service business model 1

SOURCE: Authors' own elaboration.

improving agricultural employment opportunities, attracting young talent, and creating conditions for rural women to participate in agricultural production (Figure 16).

China is actively developing new business models for hire services, with agricultural mechanization as a starting point to promote a new model of industrial development and lead the diversified development of hire services.

Agricultural mechanization hire service business model 1: A new agricultural business entity provides centralized mechanized land management or agricultural mechanization hire services for scattered lands (smallholders). The content of hire services along the agrifood value chain includes whole-process mechanized production in the field and mechanized post-harvest, storage, and processing. This can increase the added value of agricultural products and promote brand building. The business entity can also develop market access through e-commerce (online) or an offline sales network. The integration of mechanization with agronomy and digitalization promotes the development of the agricultural industry and enhances the sustainability and resilience of agrifood systems (Figure 17).

Agricultural mechanization hire service business model 2: Agricultural supply and marketing cooperatives provide a unified supply of agricultural inputs (e.g. seeds, pesticides and fertilizer) and acquisition and sales of agricultural products for smallholders, whereas the agricultural mechanization cooperatives provide comprehensive whole-process mechanization hire services for smallholders. Through providing a combination service of supply and marketing with mechanization, the agricultural cooperatives play an important role in leading smallholders towards sustainable agricultural development (Figure 18).

Agricultural mechanization hire service business model 3: This new agricultural business entity provides centralized mechanized land management or agricultural mechanization hire services for scattered lands (smallholders). The hire services include whole-process mechanized production in the field and mechanized post-harvest, storage, and processing. This can increase the added

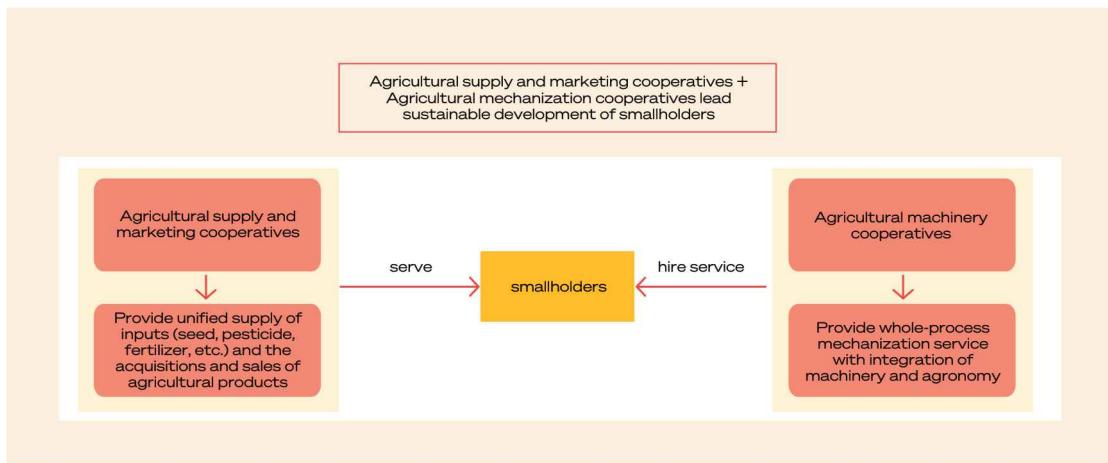


Figure 18
Agricultural mechanization hire service business model 2

SOURCE: Authors' own elaboration.

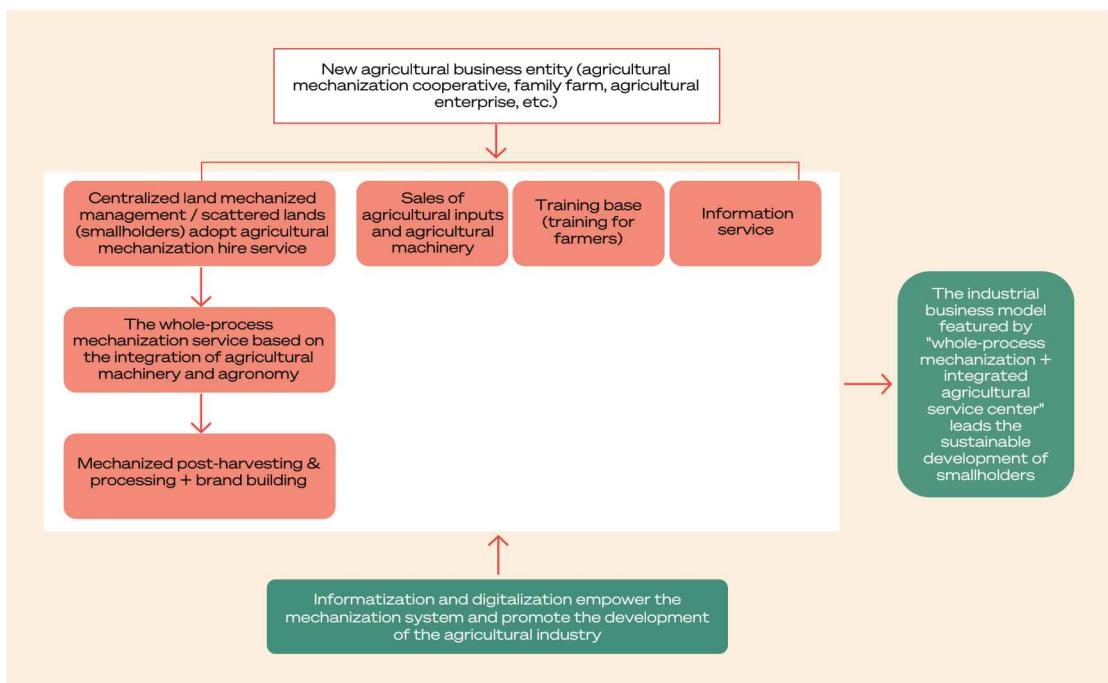


Figure 19
Agricultural mechanization hire service business model 3

SOURCE: Authors' own elaboration.

value of agricultural products and promote brand building. In addition, it provides a supply of agricultural inputs (e.g. seed, pesticides and fertilizer) and sales of agricultural machinery. It also serves as the training base for smallholders and provides an information service. This business model features whole-process mechanization and an integrated agricultural service centre, which leads the sustainable development of smallholders and promotes development of the agricultural industry (Figure 19).

8.2 CASE STUDIES OF SUSTAINABLE AGRICULTURAL MECHANIZATION BUSINESS MODELS IN CHINA

8.2.1 Rice whole-process mechanized production and digital management platform

Features: cooperation between enterprises, universities and cooperatives; partially funded by government; company capital investment; and in PPP mode.

This project, which is an example of PPP mode, was jointly conducted by Golden Datian Technology Co., Ltd., and China Agricultural University. The integrated application of Beidou navigation and real-time kinematic (RTK) differential technology has realized precision mechanization in the whole process of rice production. In addition, a digital intelligent agricultural management platform for rice production has been developed. Experiments and demonstrations were carried out in 26 demonstration villages in Jiangxi Province and Zhejiang Province, covering a total area of 265 000 mu (17 666.7 ha). This has supported 3200 households (8200 farmers) covering 13 000 mu of land in Jianggang County, Jiangxi, to achieve common prosperity. Remarkable economic, social, and ecological benefits have been created through cost saving, increasing productivity and added value, service demonstrations, post-production recycling, and so forth.

8.2.2 Mechanization in post-harvest contributes to poverty alleviation and industrial development in hilly and mountainous areas

Features: cooperation between universities, government, enterprises, production bases, and cooperatives; university self-raised funds; company capital investment (CNY 3 million); partially supported by government (construction of the dryer room); and in PPP mode.

In 2017, the Industry-Academia Integration and Sustainable Agricultural Mechanization Supporting Targeted Poverty Alleviation activity was implemented in nine provinces and 18 poverty-stricken counties, including 26 cooperatives and farms. Among them, eight of the nine provinces are typical hilly and mountainous provinces in South China.

This activity was jointly initiated by the China Agricultural Mechanization Development Research Centre at China Agricultural University and Shanghai Sanjiu Machinery Co., Ltd., under the guidance of the Agricultural Mechanization Management Department of MARA, united with the Agricultural Machinery Test and Appraisal Station and the Agricultural Mechanization Technology Development and Extension Station of MARA, the local agricultural machinery supervisory and extension departments of Jiangxi, Hubei, Hunan, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Hebei, and other provinces (cities, districts), and the Chinese Academy of Engineering.

During the activity, Shanghai Sanjiu Company donated 28 sets of dryers, with a value of nearly CNY 3 million (including shipping and installation fees), to promote the mechanization of local post-harvest and processing and the development of the agricultural industry.

Follow-up investigations, telephone interviews, technical guidance, training and inspection, machinery maintenance, seminars, and workshops have been conducted for the cooperatives that received dryers to guide the agricultural mechanization cooperatives to use the dryers as part of their hire service. This activity significantly contributes to the development of the surrounding poor households, extending the industry chain, and increasing the benefits of large-scale producers, cooperatives and family farms.

RICE WHOLE-PROCESS MECHANIZED PRODUCTION AND DIGITAL MANAGEMENT PLATFORM

Golden Datian Technology Co., Ltd. has cooperated with China Agricultural University to establish a rice smart farm (over 10 000 mu) based on mechanization and digitalization along the value chain in Nanchang County, Jiangxi Province. The farm has supported more than 8600 farmers to achieve common prosperity. Land transfer and trusteeship significantly contribute to the large-scale mechanized production. Additionally, a whole-process mechanization and digital management platform for rice production (SAMS) has been developed. The integrated application of Beidou navigation, Real-Time Kinematic (RTK) and other technology has realized precision mechanization in the whole process of rice production.

The main intelligent technologies applied in whole-process mechanized rice production involve:

- *Laser land levelling operations based on Beidou navigation*: increased seedling transplanting by 3–5 percent and expected yield by 3–5 percent.
- *Digital management of seedling breeding shed*: increased overall good-quality seedlings by 5–10 percent.
- *Precision seedling transplanting based on Beidou navigation*: decreased seedling loss by 3–5 percent.
- *Identification of missing transplanting rate after transplanting*: multispectral UAV was used to collect field data combined with AI identification technology. Increased yield by 3–5 percent.
- *Identification of seedling survival rate*: UAVs were used to collect field data combined with AI identification technology. Decreased loss by 3–5 percent.
- *Identification of weeds*: multispectral UAVs were used to collect field data combined with AI identification technology. Decreased yield loss by 3–5 percent.
- *Pest and disease identification technology*: multispectral UAV and video monitoring equipment were integrated to identify rice diseases and insect pests combined with AI recognition algorithm technology. Yield increased by 3–5 percent.
- *Precision fertilization operation based on Beidou navigation*: decreased fertilizer use by 10–30 percent.
- *Precision pesticide application based on Beidou navigation*: saved pesticide use by 10–15 percent.



Intelligent technologies applied in whole-process mechanized rice production

- *Precision pesticide application operations by plant protection UAV:* can save pesticide use by 10–15 percent and decrease water consumption by more than 90 percent.
- *Rice yield estimation and optimal harvest time prediction:* the application of satellite remote-sensing technology and multispectral UAV acquisition of field data combined with AI recognition algorithm technology. Ensures high quality and high yield of rice.
- *Precision harvesting operations based on Beidou navigation:* can decrease yield loss by 1–2 percent.

Additionally, advanced technology and equipment significantly improve green storage and processing technologies and added value of rice. A digital storage centre has been established with integrated storage equipment, sensors and automated control systems. Moreover, a digital rice processing centre has been established with integrated rice-processing equipment, sensors, and weighing and testing equipment. Selected high-quality rice can increase overall revenue by 5–10 percent.



Digital Storage and Processing Centres for Rice

A digital management platform for whole-process mechanized rice production has been developed based on web and mobile apps and has realized information management such as basic information on farms, employees, equipment, arable land, crops, production inputs, and warehouses. Additionally, it can carry out digital management of whole-process agricultural production, including land management, production planning and operations, use of agricultural inputs, field inspections, smart decision-making, internet of things monitoring, smart irrigation, agricultural product traceability and visualization platforms. Additionally, the technologies and platforms could also be applied to the other crops during crop rotation, to further optimize the sustainable cropping system.



Based on Web and Mobile Apps

SOURCE: Authors' own elaboration. Photos provided by Keming Wu, Golden Datian Technology Co.,Ltd.

INDUSTRY-ACADEMIA INTEGRATION AND SUSTAINABLE AGRICULTURAL MECHANIZATION SUPPORTING TARGETED POVERTY ALLEVIATION ACTIVITY

Industry-Academia Integration and Sustainable Agricultural Mechanization Supporting Targeted Poverty Alleviation activity has contributed to establishing an industrial model that adopts mechanization in post-harvest processing to lead the development of smallholders in the poverty-stricken hilly and mountainous areas. The main experience and achievements are the following:

- Guiding agricultural mechanization cooperatives to promote whole-process mechanized production, purchase rice from nearby farmers for mechanical drying and deep processing of rice and register rice brands to achieve added value.
- It has been proven that the drying process has achieved good economic benefits, including drying grain (97 percent is rice), rapeseed, camellias, peppers, fungi, Chinese medicinal herbs, and walnuts. Drying rice can decrease the broken rate (loss) by 10 percent compared with the traditional drying method, increase income by nearly CNY 500/tonne of rice, and save costs by about CNY 400. After drying and processing, the added value of rice is about CNY 2300/tonne.
- Dried Chinese medicinal herbs have an added value of about CNY 15 000/tonne.
- Dried chilli peppers have an added value of more than CNY 6000/tonne vis-à-vis fresh chilli peppers.
- Dried camellia seeds have an added value of about CNY 6000/tonne vis-à-vis fresh ones. In addition, processing camellia oil can double the value of dried camellia seeds.
- Approximately 2000 poverty-stricken households (more than 3500 people) were assisted and the average annual income of poor households increased by CNY 1200.



© CAU/Minali Yang

Agricultural Machinery Donation Ceremony and Field Research in the Industry-Academia Integration and Sustainable Agricultural Mechanization Supporting Targeted Poverty Alleviation Activity.



© CAU/Minali Yang

Training and Technical Guidance of the Industry-Academia Integration and Sustainable Agricultural Mechanization Supporting Targeted Poverty Alleviation Activity.

SOURCE: Authors' own elaboration.

MS JIANG MINGLAN AND PLANT PROTECTION DRONES

- Ms Jiang Minglan was one of the *first young women* to bring drones to rural areas.
- In 2020, the spring farming season was a critical period for COVID-19 prevention and control. Jiang Minglan organized for 120 drones to provide local farmers with a “contactless” pesticide application service, covering a total area of 80 000 mu (5333.33 ha).
- This minimized the impact of the COVID-19 pandemic on agricultural production and avoided the loss of production due to labour shortage.
- Ms Jiang Minglan was selected as a “2020 Food Hero” by FAO.



© Guangzhou Jifei Technology Co. Ltd. (XAG)

“2020 Food Hero” Ms Jiang Minglan

SOURCE: **Guangzhou Jifei Technology Co. Ltd (XAG)**. 2021. *Corporate Social Responsibility Report 2020*. Guangzhou, China. 62 pp. static.xag.cn/img/about/csr/xa-csr.pdf

8.2.3 Agricultural drone technology empowers women in agriculture

Features: empowerment of women, mechanized plant protection; and drone technology.

In rural areas, women account for a large proportion of agricultural labour and they often also undertake a large amount of invisible and unpaid housework and engage in production activities. Although they do a lot of hard work, their value in agriculture is often not truly reflected. Moreover, women are often marginalized in agricultural production because traditional agriculture mainly relies on male power or large and heavy tools; this is coupled with limited work and educational opportunities and production resources, hidden discrimination in employment, physical fitness gaps, and other factors. Although rural women have the same capacity for learning and enterprise, their potential in agricultural production has not been fully stimulated and their personal and career development needs cannot be effectively met.

Intelligent agricultural technologies can narrow the development gap between rural and urban areas and help to increase the economic decision-making power of rural women and promote gender equality in rural areas.

MS SHENG GUANGNING AND PLANT PROTECTION DRONES

- Ms Sheng Guangning was determined to introduce drones to support agricultural development in her hometown.
- In 2017, she obtained a specialized UAV operation certificate and instructor certificate and became a female agricultural UAV pilot.
- She founded an e-commerce plant protection company.
- At present, more than half of the major growers in Zhangjiakou City of Hebei Province are using Sheng's UAV plant protection service.
- She has attracted many young people to join her team, which has boosted local employment and social development.



Ms Sheng Guangning, the Woman Operator of Plant Protection Drones.

SOURCE: **Guangzhou Jifei Technology Co. Ltd (XAG)**. 2021. *Corporate Social Responsibility Report 2020*. Guangzhou, China. 62 pp. static.xag.cn/img/about/csr/xa-csr.pdf

In the past, because of gender bias in the technology industry, there were few women operators of drones and even fewer women engaged in the field of plant protection drones. China Guangzhou Jifei Technology Co., Ltd. (known as XAG), through continuous R&D and innovation in agricultural drones, contributes to removing agricultural technological barriers, eliminating gender discrimination in traditional agricultural equipment, and creating more opportunities and development possibilities for rural women, thus enabling them to achieve self-value in agriculture.

Agricultural drone technology empowers women in agriculture. XAG introduces equal, reciprocal, and more inclusive unmanned technology to rural areas, breaks physical limitations and the traditional division of labour between men and women in agriculture, and helps rural women get rid of complicated and tiring farming activities. It also provides modern agricultural skill training for rural women, thus giving them the professional ability to engage in agricultural production and increase income.

HAIBIN AGRICULTURAL MECHANIZATION SPECIALIZED COOPERATIVE IN LIYANG CITY, JIANGSU PROVINCE

Chairperson Wang Haibin is a demobilized soldier. The cooperative has 4600 mu of contracted land (land circulation and land trusteeship) and provides hire services for 9000 mu of external lands. The agricultural mechanization cooperative adopts the model of “farmland improvement + seed treatment + mechanized seedling nursery + whole-process mechanized production + post-harvest processing + logistics + information technology” and has formed a resource-saving and environmentally friendly agricultural production system and achieved good economic benefits. The main technologies are the following:

- The adoption of plant protection drones in field management operations has effectively improved efficiency, decreased pesticide application by 10 percent, and saved costs by more than 20 percent.
- The adoption of post-harvest equipment along the rice value chain has realized the whole-process mechanization of harvesting, drying, polished processing and product bagging, thus increasing the added value of the agricultural product by more than 45 percent.
- Installing global positioning systems (GPSs) on tractors and combine harvesters has achieved real-time information collection, statistics and rational deployment of machinery and equipment in field operations, which has increased efficiency by more than 5 percent and saved management costs by 40 percent.



Haibin Agricultural Mechanization Specialized Cooperative in Liyang City, Jiangsu Province.

SOURCE: Authors' own elaboration.

© CAU/Mini Yang

YONGFU AGRICULTURAL MACHINERY COOPERATIVE, ANZHOU DISTRICT, MIANYANG CITY, SICHUAN PROVINCE

In 2019, this cooperative was selected as a typical case in the first batch of the *National Whole-Process Mechanization + Integrated Agricultural Service Centres*. The cooperative implements order-based agricultural mechanization hire services, innovatively establishes an “integrated agricultural mechanization hire service supermarket”, and provides a one-stop service package to solve farmers’ production problems. The main experiences and achievements are the following:

- The establishment of “six centres” and a “hire service supermarket” is the key to whole-process mechanization and integrated agricultural hire services. The “six centres” are a (1) rice nursery and transplanting centre, (2) plant protection centre, (3) drying centre, (4) storage centre, (5) processing centre, and (6) agricultural machinery training centre. The modern agricultural hire service supermarket mainly provides services such as technology, agricultural inputs, production, e-commerce, and information services.
- With the “supermarket” as the platform, the cooperative developed the “whole-process mechanization + integrated agricultural hire services” business model for small-scale farmers and large-scale producers, including agricultural input sales and distribution, mechanized land preparation, mechanized seeding, mechanized plant protection, mechanized harvesting, and mechanized straw returning, drying, and sales. It provides one-stop solutions and services for farmers and solves their problems in plant production and protection.
- Integrating resources has improved the cooperative’s comprehensive service capabilities such as appropriate scale, standardization, and whole-process service, and realized the connection of smallholders and modern agricultural development with the most economical investment.
- Implementing “order-based” mechanization hire services can stabilize the service market. The cooperative expands its scale by actively attracting members to take shares in members’ machinery, capital, land, and other items, and establishes hire service packages such as planting services, partial or full land trusteeship services, and order services.

8.2.4 Agricultural mechanization cooperatives lead the development of smallholders to achieve common prosperity (PPP mode)

The Chinese Government strongly supports the development of agricultural mechanization hire service providers and organizations, especially agricultural mechanization cooperatives. As of the end of 2020, the number of agricultural mechanization service organizations in China had reached 194 500, including nearly 80 000 agricultural mechanization cooperatives.

Agricultural mechanization cooperatives can receive agricultural machinery purchase subsidies and operation subsidies (e.g. mechanized subsoiling operation subsidies). In addition, the Chinese Government encourages cooperatives to carry out land circulation and land trusteeship, especially encouraging the whole village as a unit to promote land circulation and land trusteeship, and provides special operation subsidies to mechanization hire services for land trusteeship.

- Establishing a flexible mechanism achieves a win-win situation of cooperation. Cooperation with universities and research institutes such as the Southwest University of Science and Technology, Sichuan Agricultural Machinery Research Institute, and Mianyang Academy of Agricultural Sciences provides technical support for the cooperative. Additionally, the cooperative collaborates with local villages, cooperatives, large-scale producers, family farms, and enterprises to provide whole-process mechanization and integrated agricultural hire services, and win-win cooperation is the guarantee.
- Building a brand of agricultural products to improve comprehensive socioeconomic and environmental benefits. The cooperative has established a pollution-free rice production base. The product “Huangtudi fragrant rice” has been reviewed by the China Food Development Centre and recognized as a Grade A food product. It has obtained the Green Food certification mark and achieved good brand benefits.
- Undertaking social responsibility. The cooperative has helped 99 poor households eliminate poverty.



© CAU/Mini Liang

Yongfu Agricultural Machinery Cooperative, Anzhou District, Mianyang City, Sichuan Province.

SOURCE: Authors' own elaboration.

Consequently, under policy guidance and with subsidy support, agricultural mechanization cooperatives have developed rapidly, which has accelerated agricultural modernization in China.

8.2.5 Hire service supply-demand docking platform based on ICT

Features: ICT-based hire service; and digital and informatics technology.

In recent years, agricultural mechanization hire service online platforms and intermediary service models based on ICT (e.g. web and mobile apps) have gradually emerged in China. The value proposition of the supply-demand docking platform includes (1) timely booking of machinery operators (service providers) and identifying requests from farmers to solve their difficulties in finding machinery; (2) publishing of operation time and price intention information by farmers in advance of making appointments for suitable mechanization hire services; (3) solving the problem of idleness of agricultural machinery and

DUDU OPERATION ONLINE PLATFORM OF THE “NEW FARMER • WORK TOGETHER” INTERNET OF THINGS (IOT) SYSTEM

Dudu Operation (hire service supply-demand docking online platform) is the main content of the “New Farmer • Work Together” IoT system developed by Datian Company. It is an agricultural mechanization hire service docking platform built for service providers and demanders as well as the supply and demand trading platform between agricultural producers and machinery operators.

- Machinery operators can publish service capabilities on the platform, agricultural producers can publish service requirements, and the platform provides information matching and docking for both supply and demand.
- With the core contents of high efficiency and effectiveness, Dudu Operation provides convenient and efficient supply-demand docking and scheduling services for agricultural producers, especially for smallholders.

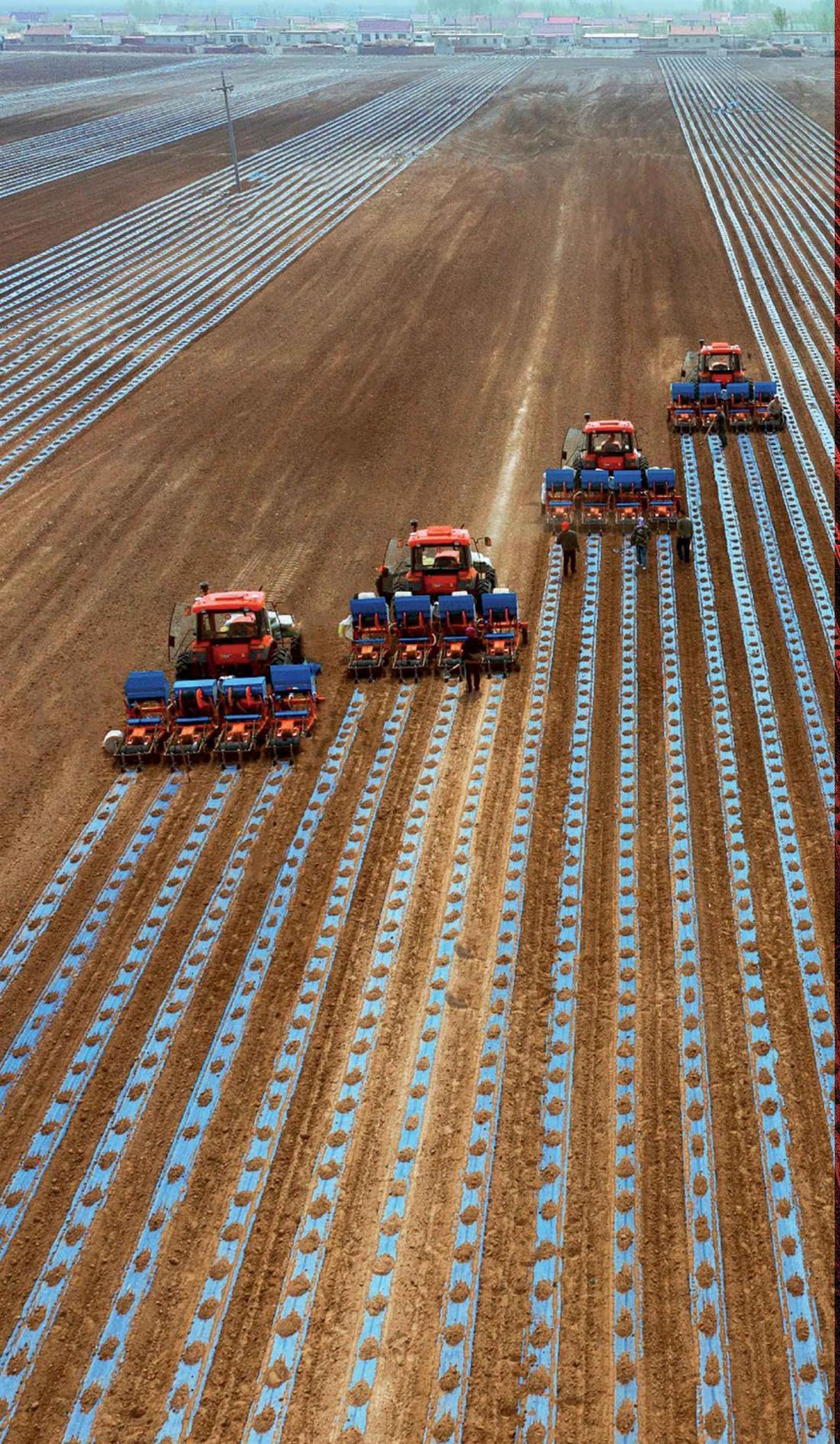


Dudu Operation Online Platform of the “New Farmer • Work Together” IoT System.

SOURCE: Authors' own elaboration. **Datian Farming Service**. 2020. “New Farmer • Work Together” Agricultural Service in China. In: *Nongji 360*. Cited 30 May 2021. <http://news.nongji360.com/html/2020/07/247844.shtml>

Pictures provided by Keming Wu, Golden Datian Technology Co.,Ltd.

increasing hire service income; (4) docking with agricultural hire service centres and daily service information such as gas stations; (5) accessing flexible, fast and secure payment methods; and (6) being combined with the internet of things to improve service efficiency and quality, and so forth.





Chapter 9

Perspectives

From the perspective of the development situation of global agricultural modernization and mechanization, modern agriculture is based on mechanization along the value chain, and characterized by appropriate scale, standardization, specialization, digitalization, automation, and intelligence. Whole-process mechanization will be achieved in different sectors (e.g. crop production, forestry, livestock, aquaculture and fisheries) and in various agricultural regions, with the technological, institutional and policy innovations as accelerators. Furthermore, the added value of agricultural products will be significantly enhanced through mechanization in protected agriculture.

With the deep integration of digitalization and agriculture the third agricultural revolution, the Agricultural Digital Revolution, is coming and various countries have made strategic arrangements for smart agriculture. Smart agriculture will be the main direction of agricultural development and it has already been promoted and adopted in some developed countries. China will also realize the integration of mechanization and digitalization in various industrial fields and establish a mechanized production system based on digital agriculture. Smart agriculture scenarios will gradually be displayed on China's large-scale farms. It is important to explore unmanned agricultural production systems and unmanned farm system solutions that can be replicated and scaled up, and thus make contributions to global agricultural development and food security.

In the future, international, South-South and Triangular Cooperation, as well as cooperation with international organizations, will share China's experiences in sustainable agricultural mechanization with the world and help developing countries tackle the challenges in food security and poverty reduction and improve the sustainability and resilience of the agrifood system.

9.1 THE WHOLE-PROCESS MECHANIZED PRODUCTION OF CROPS

9.1.1 Achieving the whole-process mechanized production of staple crops

Grains, cotton, oil crops, sugar crops, and other major crops will achieve whole-process mechanized production, especially in the crops and production links that currently have low mechanization levels, such as rice planting, potato planting and harvesting, rapeseed planting and harvesting, peanut planting and harvesting, cotton picking and sugarcane harvesting. These weak links will mostly achieve mechanization by 2035, gradually realize the integration of mechanization and digitalization, and achieve the high-yield, high-efficiency, low-consumption, high-quality, ecological, and safe development mode of agricultural modernization.

9.1.2 Achieving the whole-process mechanized production of special agricultural products

The aim is to gradually realize the whole-process mechanized production of suitable varieties of special cash crops, especially cabbages, small leafy and root vegetables, standard orchards and tea plantations, Chinese medicinal herbs, tropical crops, miscellaneous grains, and others. It is important to extensively conduct mechanization technology trials and demonstrations in family farms of appropriate scale, cooperatives, and demonstration bases, and strive to achieve whole-process mechanization in most large-scale planting bases by 2035.

9.2 SIGNIFICANTLY STRENGTHENING THE MECHANIZATION OF LIVESTOCK MANAGEMENT, AQUACULTURE AND FISHERIES

9.2.1 Mechanization of livestock management

By coordinating the development of facilities and equipment for livestock management, the aim is to strive to promote the mechanization of major animal production, key production links, and large-scale farms. By 2025, the overall level of mechanization for animal husbandry will surpass 50 percent. A new pattern of animal husbandry development will be established through the coordination of standardized moderate-scale production and mechanization. The large-scale production of major animal species in areas where conditions permit will take the lead in achieving whole-process mechanization. Another aim is to promote the Internet+ mode of animal husbandry mechanization and apply real-time and accurate information collection and intelligent management systems to key equipment in all links of animal production. Companies will upgrade and transform to internet of things (IoT) management and intelligent facilities and equipment, and promote the integration of digitalization into the use and management of facilities and equipment. By 2035, the production of major animal husbandry species will realize large-scale, mechanized, and standardized development.

9.2.2 Mechanization of aquaculture and fisheries

The aim is to promote the integration of aquaculture machinery and equipment with aquaculture technology. By 2025, the overall level of aquaculture mechanization will surpass 50 percent and the green and efficient aquaculture mechanization production system and its hire service system will be established. Factories, containers, and pond engineering and other recirculating aquaculture equipment will be mechanized, and aquaculture production efficiency, resource use efficiency, and environmental friendliness will be significantly enhanced. It is important to promote the application of digital and information technologies such as the internet of things, big data, mobile internet, intelligent control, and satellite positioning in aquaculture equipment, production operations, and

management services. It is also essential to promote intelligent facilities and equipment, along with precision production management, and to strengthen the networking of business services. By 2035, the production of major aquaculture varieties will achieve large-scale, mechanized and standardized development.

9.3 ACHIEVING WHOLE-PROCESS MECHANIZED PRODUCTION IN VARIOUS AGRICULTURAL REGIONS

9.3.1 Strengthening technological innovation

The aims are to carry out the investigation and release of mechanization technology and an equipment demand catalogue in the hilly and mountainous areas for the green production of special agricultural products with comparative advantages, and guide research institutes and enterprises to develop and manufacture high-efficiency agricultural machinery that meets the development needs for special crop products and special animal products.

It is important to promote the specialized appraisal of agricultural machinery in hilly and mountainous areas, speed up the test appraisal of new machinery products and purchase subsidies, and promote the transformation and application of innovative achievements.

It is essential to promote the integration of production, education, research, and application, and to accelerate development and extension of agricultural machinery suitable for the local agricultural industry.

It is also important to give full play to the role of industry associations and other social organizations, organize enterprises to carry out joint research on urgently needed equipment for poverty alleviation, formulate relevant standards and standard operating procedures, and promote technological innovation and industrialization.

9.3.2 Strengthening institutional innovation

The aim is to optimize the institutional arrangements and processes of national and provincial agricultural mechanization development coordination and enhance the support from finance, industry and information technology, science and technology, development and reform, and other departments.

It is important to strengthen cooperation within agricultural and rural departments in aspects of agricultural mechanization and farmland construction, plant and animal production, technology, and others; accelerate areas such as institutional innovations to promote the integration of machinery and agronomy and the integration of mechanization and digitalization, the adaptation of mechanization to farmland construction, well-facilitated farmland construction, and the suitable-for-mechanization transformation of varieties, environmentally sustainable production and management, and post-harvest processing; and improve the agrifood system with good-quality land, seeds, optimized law and policy, good agricultural practice, and good-quality machinery.

It is essential to establish a promotion mechanism for the coordinated development of public welfare and business; guide diversified social forces to engage in the promotion of public-welfare technology through government ordering, purchasing services, bidding, targeted entrustment, and financial subsidies; and accelerate the extension and service capacity of agricultural mechanization in hilly and mountainous areas.

9.3.3 Strengthening policy innovation

The aim is to innovate policy measures for the suitable-for-mechanization transformation of farmland in the hilly and mountainous areas, formulate work

guidelines, expand funding and investment channels, and carry out pilot demonstrations with the objectives of increasing efficiency and productivity and improving environmental services to achieve overall sustainability of the production systems.

Other aims are to innovate the subsidy policy supporting method for purchasing agricultural machinery in hilly and mountainous areas; prioritize funding needs in the hilly and mountainous areas; expand the subsidy scope for applicable machinery and equipment in hilly and mountainous areas; explore subsidies for the machinery and equipment needed for developing special agricultural product industries; implement subsidies after the construction and installation of facilities; and encourage comprehensive subsidy methods that will draw together elements such as purchase subsidies, loan interest discounts, and financial lease subsidies.

It is important to actively promote projects on setting up agricultural machinery operation subsidies, establishing mechanization service organizations, demonstrating and extending new mechanization technologies, and so forth. It is also important to support agricultural mechanization hire service organizations to carry out new business models and moderate-scale management through cross-regional operations, order-based operations, agricultural production trusteeships and other forms, and optimize machinery operation services, maintenance, technical training, and other capabilities to accelerate the demonstration and extension of agricultural mechanization.

Other aims are to promote the construction of agricultural mechanization talent teams in hilly and mountainous areas; continuously carry out capacity development for human resources in sustainable agricultural mechanization; select and cultivate a group of field experts in agricultural mechanization extension services; and support and guide college graduates and other personnel returning to rural areas to establish and lead new agricultural mechanization service organizations.

9.4 SIGNIFICANTLY ENHANCING THE ADDED VALUE OF AGRICULTURAL PRODUCTS THROUGH MECHANIZATION IN PROTECTED AGRICULTURE

The aims are to optimize the regional layout of facilities for plant production and promote standardized greenhouses suitable for mechanized production; speed up the integration of facility equipment, facility-specific plant varieties, and green and efficient protected cultivation techniques; improve related technical equipment and hire service systems; and promote high-quality and efficient development of whole-process mechanization in protected agriculture.

By 2025, the regional layout of facilities for plant production will be more rational and the structure types will have been improved. The total area of protected agriculture and protected cultivation will reach more than 2 million ha, mainly based on plastic greenhouses, solar greenhouses and multispan greenhouses.

The aim is to accelerate the promotion of new varieties, technologies, and models suitable for mechanized production. Mechanized technology and equipment systems and hire service systems will be established for the major horticulture varieties of protected agriculture, such as vegetables, flowers, fruit (fruit trees), and Chinese medicinal herbs. The overall mechanization level in protected agriculture will also surpass 50 percent.

Another aim is to enhance intelligent facilities and equipment. Intelligent technologies such as automatic environmental control, integrated intelligent control of fertigation, and crop growth information monitoring will

be widely used to diminish production costs and optimize the mechanization level in protected agriculture.

Key technology, equipment and facilities in protected agriculture will see breakthroughs in areas such as special sensors, automatic operations, precision operations, and intelligent operation and maintenance management. The images of agricultural robots working on grafting, pollination, inspection, and harvesting, and fully automatic plant factories will become a reality in actual production. Additionally, online information perception, precision production control, and efficient and intelligent management will be widely applied.

9.5 MECHANIZATION AND DIGITALIZATION INNOVATIONS WILL BE EXTENSIVELY ADOPTED IN AGRICULTURAL MECHANIZATION MANAGEMENT, MONITORING AND SERVICES

Beidou monitoring for agricultural machinery operations will be widely promoted. Establishing the platform for monitoring and dispatching agricultural machinery operations will enable coordination of the dynamic status of national agricultural mechanization in agricultural production and achieve good interaction and video connection for dispatching commands to ministries, provinces, cities and counties.

Precision operations of agricultural machinery will be widely adopted. Precision land levelling, precision seeding, precision fertilization, precision pesticide application, precision harvesting and autonomous driving technologies will be widely adopted. Smart production technology systems for typical regions and major crops will be established. Additionally, unmanned farms will be tested and demonstrated widely.

The agricultural mechanization management service system will be established and optimized. The aim is to establish a national agricultural mechanization management service system to realize the interconnection of different systems, including agricultural machinery test identification, safety supervision, technology extension, application guidance, public services, development monitoring, and basic information management service.

9.6 DEMONSTRATION CASES OF FUTURE FARMS IN CHINA

China has made some important explorations into the field of unmanned farms. In the next five years (Fourteenth Five-Year Plan period), various provinces will implement more projects on establishing unmanned farm demonstration bases suitable for local agricultural production. These demonstration unmanned farms reflect the future farms in China.

9.7 STRENGTHENING INTERNATIONAL EXCHANGES AND COOPERATION TO ACHIEVE WIN-WIN DEVELOPMENT

China adheres to the principles of reform and opening up, actively responds to the Belt and Road Initiative (Belt and Road Portal, 2017), and adheres to the path of internationalization and sustainable development. This will further accelerate international cooperation in agricultural mechanization and enhance the “bringing in” and “going global” of agricultural mechanization.

The aim is to strengthen international technical cooperation and exchanges, guide domestic agricultural machinery enterprises to carry out various forms of cooperation with foreign countries, fully use foreign capital, introduce advanced technology and management experience, optimize the structure of domestic agricultural machinery manufacturing enterprises, and raise technical levels. An additional aim is to encourage and support qualified

THE PRACTICE OF BEIDAHUANG JIANSANJIANG – COUNTRY GARDEN UNMANNED FARM PROJECT

Beginning in 2020, the Jiansanjiang Branch of Beidahuang Agricultural Reclamation Group (hereafter referred to as “Beidahuang Jiansanjiang”) and Country Garden Agricultural Holdings Co., Ltd. (hereafter referred to as “Country Garden”) formulated a three-year plan to implement the Beidahuang Jiansanjiang–Country Garden Unmanned Farm Project on Jiansanjiang Qixing Farm and Erdaohe Farm of Heilongjiang Province (in Northeast China). The project focuses on an unmanned agricultural mechanization pilot and demonstration.

This project is currently the world’s largest-scale unmanned farm project focusing on staple food crops, with the most inputs of agricultural machinery and equipment in demonstrations, the most advanced unmanned technology, and the highest degree of unmanned mechanization in field operations. In 2021, it was the world’s first unmanned farm pilot and demonstration project of more than 10 000 mu.

This project will accelerate China’s agricultural modernization and enhance China’s green transformation and upgrading of agriculture. It will greatly improve agricultural productivity and ensure Chinese food security. It is a milestone in the development of modern agricultural science and technology in China. Additionally, it provides an unmanned production system and unmanned solutions that can be replicated and popularized, which is an important contribution to global agricultural development and food security. Tasks and goals of the project follow:

- Completion of trials and demonstrations of unmanned field operations of agricultural machinery and unmanned technologies in various agricultural production links will be achieved.
- Optimization of key technologies such as straight-line operation of unmanned machinery driving technology, field turning and U-turning, path planning, intelligent control, automatic lifting of agricultural equipment, PTO automatic clutch, automatic obstacle avoidance, operation coordination, multimachine coordination (multimachine linkage), machinery scheduling, remote monitoring, and management will be achieved.
- A high-level or a certain degree of unmanned machinery operations in agricultural production on an area of 10 000 mu, including land preparation, planting (seeding), management, harvesting, and transportation will be achieved.
- In October 2020, this project held a demonstration meeting of unmanned machinery operations on Qixing Farm. A total of 44 units of agricultural machinery and equipment demonstrated more than 20 types of unmanned machinery operations, covering whole-process production of the three major crops (rice, maize and soybean) from spring to autumn.

agricultural machinery enterprises to “go global” and invest in overseas factories to drive exports of products and services.

It is important to strengthen international publicity of agricultural machinery products to expand the export of agricultural machinery products with independent intellectual property rights and brands.

It is also important to strengthen cooperation with developing countries and expand mutually beneficial cooperation and joint development. China has carried out international agricultural engineering projects in the Sudan, Ethiopia, Zimbabwe, Viet Nam, the Bolivarian Republic of Venezuela, Nigeria, Mozambique, and other developing countries, including the China-Zimbabwe Agricultural

- The key unmanned operations included the unmanned collaborative machinery operation of rice harvesting, receiving, and transporting of grain; unmanned paddy field construction; unmanned land preparation; unmanned seedling transplanting; unmanned dryland direct seeding; plant protection drones; unmanned crop residue management; and unmanned pesticide application.



© CAU/Mini Yang

Beidahuang Jiansanjiang–Country Garden Unmanned Farm Project.

SOURCE: Authors' own elaboration.

Demonstration Centre project, and the Ethiopian Teff Production Mechanization Promotion Project in cooperation with the Bill & Melinda Gates Foundation (small-scale agricultural machinery research and development), Vietnam Rice Mechanization Market Promotion Project, Venezuelan Agricultural Machinery and Agricultural and Sideline Product Processing Equipment Manufacturing Industrial Park Project, and the Cameroon Oil Extraction Project.

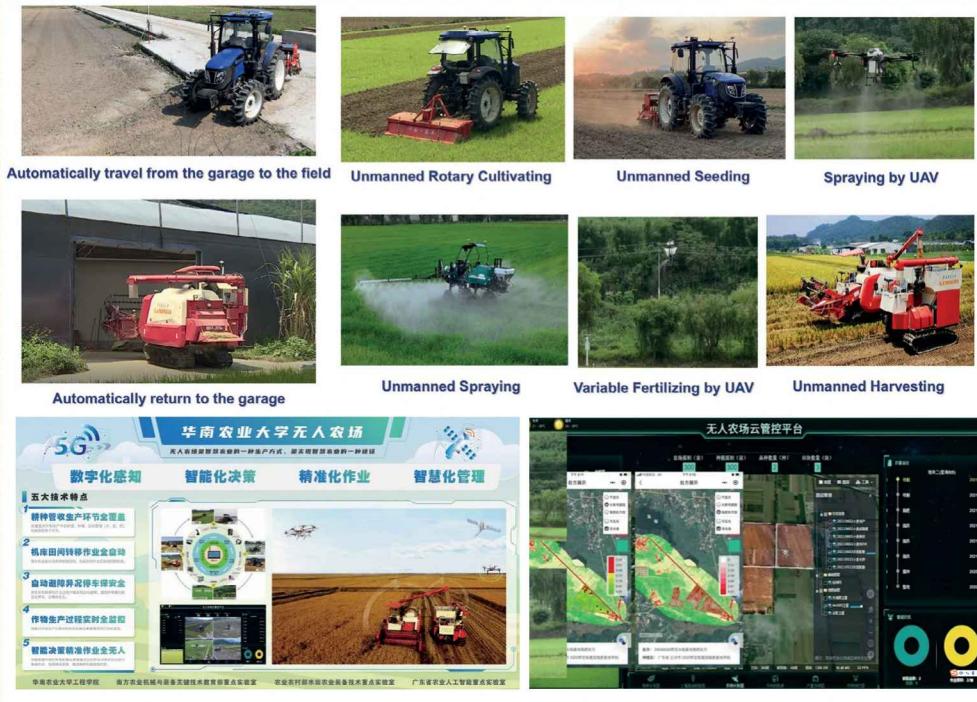
In the future, international, South–South and Triangular Cooperation, and cooperation with international organizations such as FAO, WFP, the World Bank, and CSAM, will share China's experiences in sustainable agricultural mechanization with the world, and so help developing countries tackle the challenges in food security and poverty reduction and improve the sustainability and resilience of the agrifood systems.

EXPLORATION AND PRACTICE OF UNMANNED FARMS BY SOUTH CHINA AGRICULTURAL UNIVERSITY

Since 2003, the team of the academician Professor Luo Xiwen of South China Agricultural University has carried out research on the key technologies of agricultural machinery navigation and automatic operation. Major breakthroughs have been made in ten key technologies: navigation and positioning, path tracking, electro-hydraulic steering, motor steering, speed control, machinery control, automatic obstacle avoidance, master-slave navigation, vehicle terminal and system integration. Key technological innovations are the following:

- High-precision continuous and stable positioning and attitude measurement of agricultural machinery under different operating conditions by using the combination of Beidou satellite positioning (Beidou navigation) and MEMS (i.e. microelectromechanical systems) inertial sensing has been achieved, and an innovative linear time-varying adaptive Kalman filter algorithm for external acceleration compensation has been designed.
- The tracking accuracy of paddy field agricultural machinery through innovative design of a composite path-tracking controller based on preview following, using a non-linear state observer to compensate for the side slip of the decision-making desired wheel angle, has been significantly improved.
- Effective integration and control of the agricultural machinery automatic navigation operation system through innovative design of the distributed agricultural machinery automatic navigation operation system consisting of line control and an automatic navigation operation local area network has been realized, and a multilayer intelligent control strategy and method has been proposed.
- Agricultural machinery automatic navigation line control devices and Beidou automatic navigation products for agricultural machinery with independent intellectual property rights have been created. Unmanned rotary tillers, unmanned seeders, unmanned rice transplanters, unmanned sprayers, and unmanned harvesters were developed and applied on unmanned farms.
- The unmanned farm of South China Agricultural University can achieve unmanned operations of whole-process production, fully automatic transfer operations from storage shed to field, automatic obstacle avoidance and parking system to ensure safety, real-time full monitoring of the crop production process, and intelligent decision-making and precise operations.

- The developed intelligent agricultural management system includes functional modules such as digital perception, intelligent decision-making, precise operation, and intelligent management.



Exploration and Practice of Unmanned Farms by South China Agricultural University.

SOURCE: Authors' own elaboration. Pictures provided by Lian Hu, South China Agricultural University.

BAYER, JIFEI TECHNOLOGY (XAG), AND RURAL TAOBAO (ALIBABA) JOINTLY LAUNCHED THE “SUSTAINABLE FARMING PROGRAMME”

The Sustainable Farming Programme was jointly initiated by Bayer, XAG, and Rural Taobao (Alibaba). The project invited global partners in the field of modern agricultural technology to jointly participate in the construction of a new-concept agricultural demonstration base project. Its core concept is to nurture new farmers, adopt new technologies, and practice new ideas while exploring the maximization of efficiency, protecting the environment, and realizing the sustainable development of agricultural production and ecology.

- On the Future Farm, farmers will receive support for whole-process agricultural operations, including land preparation, planting (seeding), management, and harvesting, and establish a complete intelligent agricultural management system. The precision and digital transformation of agriculture greatly decreases the uncertainty of production and gets rid of the high risks and disadvantages of conventional agriculture, optimizes productivity and minimizes losses, and increases agricultural product yield and quality.
- On the Future Farm, the crops will be traceable throughout the entire process. Farmers can check real-time crop growth status and agricultural input use (e.g. pesticide) through the cloud data management platform. Farmers can also conduct safety inspections in accordance with international green standards to ensure green and healthy agricultural products.
- Future Farm’s efficient farm management model will accurately calculate the appropriate amount of pesticide and fertilizer, reduce land and water pollution, and use sustainable agricultural technology and tools to protect natural resources and biodiversity.
- In terms of rural finance, *Ant Financial* has the capacity to provide online services, based on data risk control combined with the data of farmers and farmland accumulated by XAG, for plant protection services as well as data-based credit. It can provide convenient (internet-based) and fair financial support for farmers and participants on the Future Farm (such as drone operators).
- The internet of things and UAV technology for surveying and mapping will improve farmers’ access to intelligent perception of farmland and help them make more scientific decisions through agricultural intelligent engine analysis to optimize the use of machinery for better production.
- The Future Farm plan will be enabled through the construction of digital agricultural infrastructure, the development of precision agricultural equipment, and the implementation of smart farm management systems.

极飞科技三大主营业务



STEP 1 建设数字农业基础设施

农田高清地图
RTK 导航网络
农业物联网设备

让农事服务标准化
为智能农机铺平道路



STEP 2 开发精准农业装备

全自主农业无人机
全自主农业无人车
农机自动驾驶仪

降低劳动力成本
提高农产品质量



STEP 3 实施智慧农场管理系统

农田管理系统
AI 作物模型
农业大数据

大幅提升农业管理效率
实现产量和质量最优平衡

XAG PRODUCT LINES 极飞科技六大产品线



农业无人机



智慧农业系统



农业物联网



农机自驾仪



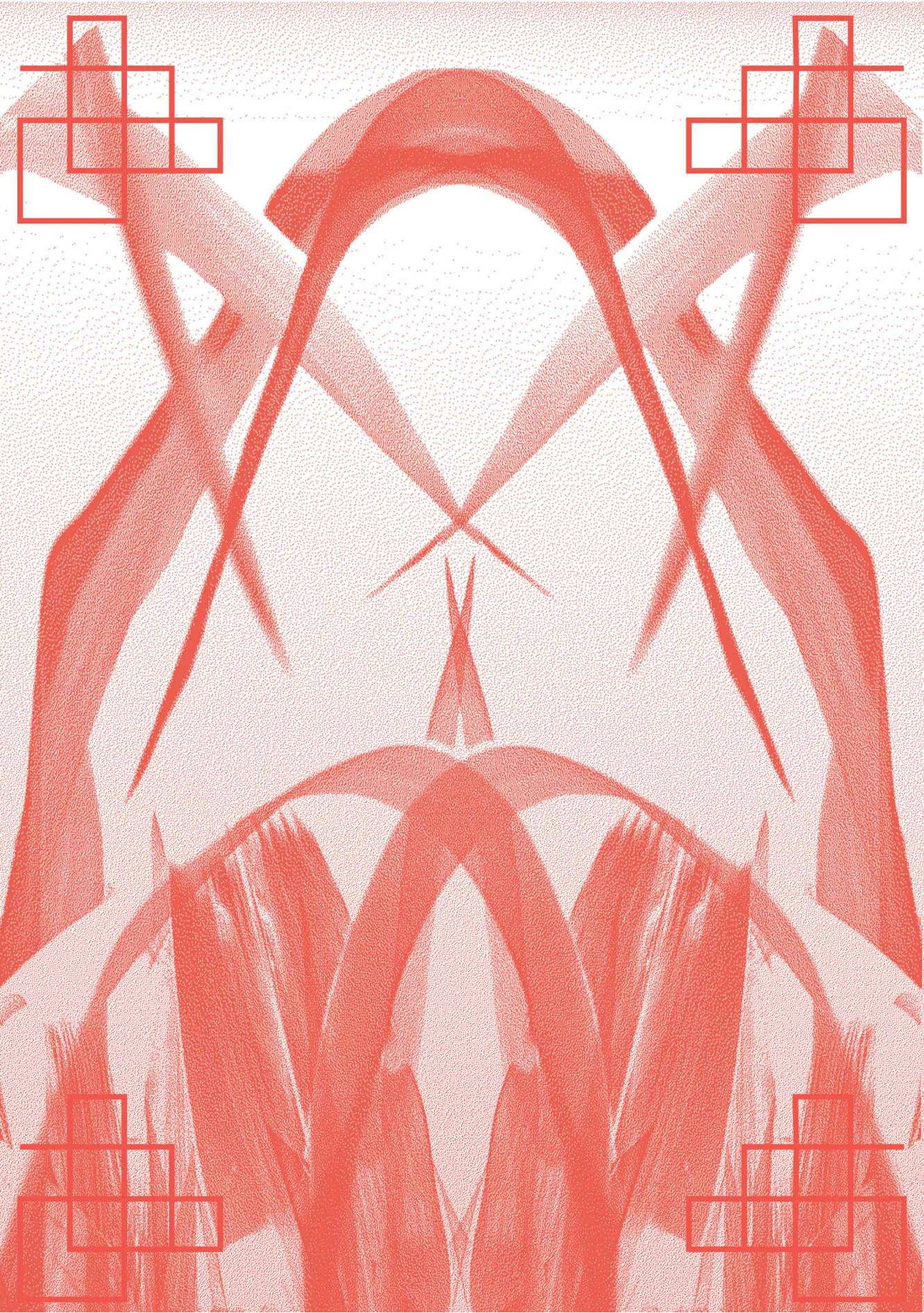
农业无人车



遥感无人机

XAG Future Ecological Farm System.

SOURCE: **Guangzhou Jifei Technology Co. Ltd (XAG)**. 2018. Sustainable Farming Programme. Cited 15 May 2021. www.xa.com/en/events/4



References

- 8WCCA. 2021. 8th World Congress on Conservation Agriculture (8WCCA). Cited 30 April 2021. <https://8wcca.org>
- AfricaMechanize. 2022. F-SAMA Virtual Webinar Series. Cited 30 April 2022. www.africamechanize.org
- BeiDou Navigation Satellite System. 2021. BeiDou Navigation Satellite System. Cited 30 April 2021. <http://en.beidou.gov.cn>
- Belt and Road Portal. 2017. *Building the Belt and Road: Concept, Practice and China's Contribution* (Seven language versions). Cited 14 March 2022. www.yidaiyilu.gov.cn/info/iList.jsp?tm_id=540
- CEMA. 2021. Advanced Farm Machines & Solutions mark the path to deliver a Sustainable Farming in Europe. Cited 30 April 2021. www.cema-agri.org/index.php?option=com_content&view=article&id=786&catid=18&Itemid=107
- Chinese State Council. 2018. *Guiding Opinions of the State Council on Accelerating Agricultural Mechanization and the Transformation and Upgrading of Agricultural Machinery and Equipment Industry* (Guofa [2018] No. 42). Cited 30 April 2021. www.gov.cn/zhengce/content/2018-12/29/content_5353308.htm
- Chinese State Council. 2021. Notice of the State Council on Printing and Distributing the "Fourteenth Five-Year Plan" to Promote the Modernization of Agriculture and Rural Areas. Cited 30 March 2022. www.gov.cn/zhengce/content/2022-02/11/content_5673082.htm
- CSAM. 2020a. Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM). Cited 30 April 2021. www.un-csam.org/ANTAM
- CSAM. 2020b. Mechanization Solutions for Improved Livestock Management and Prevention & Control of Zoonotic Diseases. Beijing. www.un-csam.org/sites/default/files/2021-01/ENG.pdf
- European Commission. 2021. A European Green Deal. Cited 30 April 2021. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en#timeline
- European Union. 2016. Regulation (EU) 2016/1628 of the European Parliament and of the Council of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery. *Official Journal of the European Union*, L252(59): 53–117. In: <http://data.europa.eu/eli/reg/2016/1628/oj>
- FAO. 2021a. FAO Global Sustainable Agriculture Mechanization Community of Practice. Cited 30 April 2021. <https://dgroups.org/fao/mechanization>
- FAO. 2021b. FAO launches Global Action on One Country One Priority Product. Cited 28 February 2022. www.fao.org/news/story/en/item/1438036/icode
- FAO. 2022a. Sustainable Agricultural Mechanization. Cited 30 April 2021. www.fao.org/sustainable-agricultural-mechanization/en

- FAO. 2022b. *Conservation Agriculture*. Cited 30 April 2021. www.fao.org/conservation-agriculture/en
- FAO. 2022c. *FAO elearning Academy*. Cited 30 April 2021. <https://elearning.fao.org>
- FAO & AUC. 2018. *Sustainable Agricultural Mechanization: A Framework for Africa*. P. Kormawa, G. Mrema, N. Mhlanga, M.K. Fynn, J. Kienzle & J. Mpagalile, eds. Addis Ababa, FAO. www.fao.org/3/CA1136EN/ca1136en.pdf
- Farmers Daily.** 2020. *Academician and Agricultural Expert Teams Supporting Spring Farming*. Cited 30 April 2021. www.kjs.moa.gov.cn/gzdt/202003/t20200330_6340134.htm
- Guangdong Provincial Agricultural Non-point Source Pollution Control Project Management Office.** 2021. *Comprehensive information network of Guangdong agricultural non-point source pollution control project loaned by World Bank*. In: www.gdmy.org
- ITU.** 2021. FAO-ITU Joint Event: Agricultural robotics for climate-resilient food production. In: *AI for Good Webinars*. Cited 30 April 2021. <https://aiforgood.itu.int/event/agricultural-robotics-for-climate-resilient-food-production>
- Jiang, S. & Kienzle, J.** 2020. Restoring agricultural production during and post COVID-19: A look into Sustainable Agricultural Mechanization (SAM) and hire services in China. In: *FAO Sustainable Agricultural Mechanization*. Cited 30 April 2021. www.fao.org/sustainable-agricultural-mechanization/resources/news/detail-events/en/c/1294566
- Justice, S., Flores Rojas, M. & Basnyat, M.** 2022. *Empowering women farmers – A mechanization catalogue for practitioners*. Rome, FAO.
- MARA (Ministry of Agriculture and Rural Affairs of the People's Republic of China).** 2019. *China's Agricultural Mechanization Management Statistical Survey System*. Beijing, China. www.moa.gov.cn/govpublic/NYJXHGLS/201902/P020190220505651335298.doc
- MARA.** 2020a. *National Modern Animal Husbandry Promotion Conference was held in Zhucheng, Shandong*. Cited 30 April 2021. www.moa.gov.cn/xw/zwdt/202011/t20201104_6355778.htm
- MARA.** 2020b. *Deputy Director Wang Jiayun of Agricultural Mechanization Management Department of MARA Attended the Press Conference of the Joint Prevention and Control Mechanism of the State Council*. Cited 30 April 2021. www.njhs.moa.gov.cn/gzdt/202004/t20200420_6341972.htm
- MARA.** 2020c. *The Ministry of Agriculture and Rural Affairs deployed cross-regional operations of agricultural machinery in 2020 summer*. Cited 30 April 2021. www.njhs.moa.gov.cn/gzdt/202005/t20200515_6344093.htm
- MARA.** 2020d. *A Proposal to Farmers' Cooperatives Across the Country*. Cited 30 April 2021. www.moa.gov.cn/ztzl/kjxgfy/202002/t20200206_6336647.htm
- MARA.** 2020e. *National Emergency Response Plan for Cross-Regional Agricultural Mechanization Operations in 2020 Summer*. Beijing, China. www.njhs.moa.gov.cn/gzdt/202005/P020200518303136825627.pdf
- MARA & MOF (Ministry of Finance of the People's Republic of China).** 2020. *Action Plan for Conservation Agriculture of Black Soil in Northeast China (2020–2025)*. Cited 10 April 2021. www.moa.gov.cn/nybgb/2020/202004/202005/t20200507_6343266.htm
- MARA & MOF.** 2021. *Guiding Opinions on the Implementation of Agricultural Machinery Purchase Subsidies 2021–2023*. Cited 30 March 2022. www.moa.gov.cn/govpublic/CWS/202104/t20210406_6365311.htm

- MEE (Ministry of Ecology and Environment of the People's Republic of China).** 2014. Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (CHINA III, IV). In: *Emission Standard for Mobile-source Pollutants*. Cited 20 April 2021. https://english.mee.gov.cn/Resources/standards/Air_Environment/emission_mobile/201605/t20160511_337514.shtml
- MEE.** 2020. *Announcement on the Issuance of National Environmental Protection Standards: Technical Policy for the Emission Control of Pollutants from Non-Road Diesel Mobile Machinery*. Cited 20 April 2021. www.mee.gov.cn/xxgk2018/xxgk/xxgk01/202012/t20201231_815661.html
- Mrema, G., Soni, P. & Rolle, R.S.** 2014. *A regional strategy for sustainable agricultural mechanization: Sustainable mechanization across agri-food chains in Asia and the Pacific region*. Bangkok, FAO. www.fao.org/3/i4270e/i4270e.pdf
- National People's Congress of the People's Republic of China.** 2018. *Law on Promotion of Agricultural Mechanization of the People's Republic of China*. Cited 30 April 2021. www.npc.gov.cn/zgrdw/npc/xinwen/2018-11/05/content_2065668.htm
- Sims, B., Kahan, D., Mpagalile, J., Hilmi, M. & Valle, S.S.** 2018. *Hire Services as a Business Enterprise: A Training Manual for Small-Scale Mechanization Service Providers*. J. Kienzle & B. Gérard, eds. Rome, FAO and CIMMYT. <https://www.fao.org/3/I9207EN/i9207en.pdf>
- State Administration for Market Regulation.** 2022. *Briefing on 2021 State Supervision and Spot Check of Agricultural Machinery Product Quality*. Cited 20 March 2022. www.samr.gov.cn
- Takeshima, H. & Vos, R.** 2022. *Agricultural mechanization and child labour in developing countries*. Rome, FAO. www.fao.org/3/cb8550en/cb8550en.pdf
- Xinhua News Agency.** 2020. *Current Status of Chinese Dairy Industry Quality*. Cited 30 April 2021. <https://nyncw.sh.gov.cn/xyyw/20200722/abbfabcbf45e4caf975f76f01cad1af6.html>
- Xinhua News Agency.** 2021a. *The Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-Term Goals for 2035*. In: *State Council of People's Republic of China*. Cited 30 March 2022. www.gov.cn/xinwen/2021-03/13/content_5592681.htm
- Xinhua News Agency.** 2021b. *Law on Promotion of Rural Revitalization of the People's Republic of China*. Cited 30 March 2022. www.xinhuanet.com/politics/2021-04/29/c_1127393923.htm
- Xinhua News Agency.** 2021c. *Opinions of the Central Committee and the State Council on Comprehensively Promoting Rural Area Revitalization and Accelerating Agricultural and Rural Modernization*. Cited 30 March 2022. www.xinhuanet.com/politics/2021-02/21/c_1127122068.htm

Sustainable agricultural mechanization covers all levels of farming and processing technologies, and takes into consideration technological, economic, social, environmental and cultural aspects when contributing to the sustainable development of agrifood systems. This publication strives to comprehensively and systematically summarize the status and strategies of China's agricultural mechanization development, its impacts, experiences and practices, and business models. Furthermore, the publication investigates the related investment and policy recommendations to reach the goal of agricultural and rural modernization by 2035, to drive smallholder farmers to enter modern agriculture, and to achieve sustainable development. It is estimated that by 2035, agricultural production in China will predominantly be mechanized. The concept of integrating mechanization and digitalization will be applied to agricultural mechanization management and operation monitoring and services, and mechanization will comprehensively support all agricultural and rural modernization. The development of sustainable agricultural mechanization in China provides cases and examples of innovations with global value, not only for developing countries but in particular for middle-income countries and emerging countries.

This publication is part of the Country Investment Highlights series under the FAO Investment Centre's Knowledge for Investment (K4I) programme.

ISBN 978-92-5-137172-5



CC2867EN/1/01.23