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POLICY BRIEF

Gender Mainstreaming in Sustainable Agricultural Mechanization in Asia and the Pacific

Case Studies on Women's Empowerment for Innovative and Sustainable Agricultural Mechanization in China

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Executive Summary

Economic development and social progress have led to a significant increase in participation by women in agricultural mechanization. Women have demonstrated resilience, innovation, and exceptional leadership in agricultural machinery operation and management, driving advancements in food security, sustainable agriculture, and rural development. However, research studies show that women often encounter significant barriers, including limited access to technology, pervasive social stereotypes, and unequal pay, limiting their participation in social and economic activities, particularly in agricultural mechanization. Bridging this gender gap is critical to sustainably enhancing agricultural productivity, driving economic growth, and promoting rural transformation, thereby helping address the pressing challenges of food insecurity and climate change.

This study examines notable cases of women-led innovations in agricultural mechanization in China, highlighting that their role in the operation and management of agricultural machinery can mitigate labour shortages, promote standardization of agricultural practices, advance smart agricultural machinery and foster the transition to green agricultural practices. These innovations not only improve farmers' incomes but also contribute to the modernization and more inclusive and sustainable development of the agricultural sector.

The study makes the following actionable recommendations at technical and policy levels, tailored to conditions in China and with potential applicability to other countries in the Asia-Pacific region:

(1) Support and empower women for Sustainable Agricultural Mechanization

Governments and other stakeholders should prioritize women's empowerment in agriculture mechanization by supporting their roles as machinery operators, professional service team members and decision makers. Recognition of women's significant contribution to addressing labour shortages and driving the technological and green transformation of agricultural mechanization is essential. There should be focus on ensuring equal pay for equal work and eliminating social discrimination.

(2) Enhance research and development of agricultural machinery for women

Priority should be given to research and development of agricultural machinery designed to meet the needs of diverse operators, with particular attention to women. Features such as ergonomic controls, enclosed cabins and automated systems should be integrated to enhance usability, safety, efficiency, and inclusivity. Continuous improvements to farmland infrastructure to accommodate advanced machinery are also critical for creating inclusive working conditions.

(3) Expand education and training for women in professional skills

Increased access to education and training programmes is essential to develop women's technical skills in agricultural mechanization. Governments should establish quotas to ensure female participation in training programmes, develop specialized agricultural mechanization courses for women and utilize diverse training channels such as online platforms and community awareness workshops. A database of female agricultural machinery operators can also support

targeted skill-building and job-matching.

(4) Strengthen the legal framework to protect women's rights in agricultural mechanization

Robust legal frameworks are essential for safeguarding women's rights in agriculture. This includes enforcing anti-discrimination policies, ensuring equal pay for equal work and ensuring safe and equitable working conditions. Strengthened legal protections will enable women to participate fully and safely in agricultural mechanization.

(5) Develop comprehensive social support systems for women in agricultural mechanization

Recognizing women's dual roles as agricultural workers and caregivers, government authorities and local communities must implement family-friendly policies, provide childcare support, and promote flexible work arrangements. Fostering strong community and family support systems is crucial for enabling women to balance professional and personal responsibilities.

Implementing these recommendations can promote gender equality in agricultural mechanization, unlocking the transformative potential of women to drive innovation, productivity, and sustainability. Empowering women for mechanization will not only modernize agricultural systems but also catalyze social and economic progress. These recommendations are intended as a useful resource for mechanization practitioners in China and a reference for other countries in the Asia-Pacific region.

I. Introduction

Industrialization and urbanization have contributed to the growing feminization in agriculture, positioning women as key contributors to food security. In 2011, women comprised, on average, 43 per cent of the agricultural labour force in developing countries (FAO, 2011). In 2022, women accounted for approximately 29 per cent of the agricultural labour force in the United States of America, 33 per cent in Germany, 30 per cent in France, 37 per cent in Japan and 39 per cent in the Republic of Korea[1]. Women comprised about 36 per cent of workers in global agricultural food systems in 2020 (FAO, 2023).

Women's contribution to agriculture extends beyond manual labour, encompassing their expertise in agricultural practices and biodiversity. They play unique roles in areas such as biomass fuel collection, food processing and agricultural product marketing, and are responsible for the management of more than 70 per cent of the world's water resources (WHO, 2023).

Despite their significant contribution to agricultural production and rural communities, women face significant inequalities, particularly in income, earning only 82 per cent of what men earn from similar work in agriculture and encounter challenges in adapting to technologies often designed for men (FAO, 2023). It is estimated that women enjoy approximately 64 per cent of the rights of men and closing the gender gap in employment and entrepreneurship could raise global gross domestic product (GDP) by more than 20 per cent (World Bank Group, 2024). The Food and Agriculture Organization of the United Nations (FAO) estimates that closing the gap between women and men in agricultural productivity and wages in agrifood systems could increase global GDP by nearly $1 trillion dollars and lift 45 million people out of food insecurity (FAO, 2023). Accordingly, on 2 May 2024, the United Nations General Assembly adopted a resolution proclaiming 2026 as the International Year of Women Farmers, emphasizing the need to address barriers faced by women farmers in agrifood systems and promote gender equality and women's empowerment in agriculture.

Experience shows that agricultural mechanization has significantly improved the division of labour and reduced the burden on women in agricultural production. Access to digital technologies has also made it easier for women to acquire knowledge and resources needed for agricultural production enabling them to take on independent roles or share traditional male responsibilities in agricultural production (JIANG and LI, 2021). The reduced dependency on men has led young women to view roles in agriculture more positively, strengthening gender relations within the sector (HU, 2009; CAI and HUANG, 2017). This has contributed to promoting gender equality and women's empowerment in agriculture, increasing resilience to climate change, promoting sustainable agricultural development, and supporting the goals of eradicating poverty and hunger.

[1] Based on FAOSTAT data available at https://www.fao.org/faostat/en/#data

II. Case studies on women's empowerment for innovative and Sustainable Agricultural Mechanization in China

The case studies highlight the crucial role of women's empowerment in agricultural mechanization by equipping women in agriculture with the skills, resources and opportunities needed to access, operate, and benefit from modern farming machinery and technologies. By reducing labour-intensive agricultural work, mechanization enhances productivity and strengthens women's economic independence, contributing to a more equitable and sustainable agricultural sector.

Growing urbanization over the past decades in China has led to a new division of labour among rural families with men increasingly migrating to cities for better-paid work and women staying back to manage agricultural activities. The resulting "feminization of agriculture" is reshaping China's agriculture landscape with women accounting for about 65 per cent of the total number of agricultural and rural workers in the country (Ministry of Women Development, 2015), positioning them as essential contributors to farming and rural development (ZHANG, LI and JIN, 2021).

This transition is broadening women's roles and influence in agriculture, as well as within their families and communities, improving their social and economic status (MENG, 1993). As China's agriculture modernizes, advances in agricultural machinery and digital technologies such as Continuously Variable Transmission (CVT), automatic positioning, intelligent navigation and remote control are gradually reducing the physical demands traditionally associated with farming. These technological innovations are enabling women to fully engage in and adapt to modern agricultural practices.

Young women, especially in the 20–49 years age group, now comprise a sizeable segment of the rural workforce, surpassing men in numbers (YUAN and LIU, 2015). Women's active engagement in sustainable agricultural practices and their role in promoting innovative agricultural mechanization are critical to rural transformation. The following section highlights three cases of women's empowerment in promoting innovative and sustainable agriculture mechanization in China.

A. Case Study I: Female Drone Pilot

Background: Wang Min, a young woman born in the 1990s in Anhui Province in China, works with her husband as a grain and oilseeds farmer. Due to the region's hilly terrain, poor land conditions and limited government support for agricultural mechanization in Anhui province, they began leasing and operating land in areas such as Changzhou and Nanjing in Jiangsu Province where greater support was available for agricultural mechanization. Wang Min and her husband

Figure 1: Ms. Wang Min, professional agricultural drone pilot

increased their managed farmland from 20 hectares in 2016 to over 60 hectares in 2024[2]. To deal with the labour shortage during peak farming seasons and to reduce her husband's workload, Wang Min obtained a tractor driving license to assist with land tilling and preparation work.

In 2020, a local young agricultural entrepreneur introduced her to the use of crop-protection drones for remote pesticide application thereby reducing exposure to chemicals. After obtaining her drone operator certification, Wang Min advanced from an agricultural assistant to an independent provider of agricultural machinery service, earning recognition within her community for her expertise.

Wang Min's case highlights four key aspects of women's empowerment through innovative agricultural mechanization.

(1) Full mechanization of grain and oil crops

Efficient and innovative agricultural machinery such as compound seeders and crop protection drones are gradually being introduced in rice and wheat cultivation, alongside tractors and combine harvesters, resulting in the full mechanization of grain production. The use of machine harvesting was limited to 56 per cent of oilseed rape cultivation in China in 2022, compared to 98 per cent, 96 per cent and 80 per cent, respectively, for wheat, rice and corn. Wang Min boldly introduced rapeseed combine harvesters, significantly reducing reliance on manual labour and increasing production efficiency. Her efforts have set a positive example for neighbouring smallholder farmers, fostering mechanization in oilseed crop production.

(2) Expanding the application of drones

[2] In China, farmland is often increased through land transfer and subcontracting, with villages facilitating land agreements based on farmer interest or available idle land. In areas near cities, where many farmers have alternative employment opportunities, leasing arrangements are common, allowing people like Wang Min's family to engage in large-scale production, especially with older farmers who prefer to lease their land management rights.

Crop protection drones were primarily used for spraying liquid pesticides on crops but advancements in technology have significantly increased their payload capacity, from around 30 litres in 2016 to 50 litres today, allowing the spraying of both liquids and granules. A 50-litre drone can cover 30–40 hectares per day and during peak farming seasons, it can manage up to 60 hectares daily. Building on these advancements, Wang Min expanded drone applications beyond crop protection to fertilizer application and seeding. This innovation has significantly improved labour efficiency, reduced labour intensity and effectively addressed the challenges to seeding and fertilizing rapeseed in hilly areas.

(3) Application of intelligent assisted driving system

The widespread adoption of BeiDou satellite navigation and advancements in digital technologies, such as satellite remote sensing and precise positioning, have driven the rapid development of intelligent assisted driving systems[3] for agricultural machinery. Wang Min equipped her tractor with an intelligent assisted driving system, which ensures precise path alignment during operations such as trenching and seeding, reducing operational errors. This technology maximizes land use efficiency, improves the visual appeal of crop planting, and boosts the overall productivity and profitability of agricultural operations.

(4) Provision of plant protection services by drones

A skilled professional drone pilot, Wang Min manages crop protection, weeding and other tasks on the 60 hectares of land she owns. She also offers specialized drone-based crop protection services to a local cooperative covering over 650 hectares as well as neighbouring farmers. In 2023, she single-handedly provided crop protection, weeding and other services covering more than 6,500 hectares across Jiangxi and Hunan provinces.

This impressive reach is possible due to the seasonal nature of rice-wheat crop rotations in Jiangsu and Anhui, which require multiple rounds of plant protection, allowing Wang Min to offer cross-area services. Thanks to the high efficiency of drones, she can manage the operations independently, with minimal help needed for tasks such as loading water and chemicals, usually provided by local farmers. Wang Min's meticulous work, streamlined operations and outstanding results in crop protection, have earned her widespread praise from local farmers, challenging traditional perceptions of women's role in agricultural mechanization, and demonstrating their capabilities as leaders in modern, technology-driven farming.

B. Case Study II: New Sugarcane Farmer

Background: Wei Shuixiu, born in 1977 in Guangxi Autonomous Region in China, grows sugarcane in one of the most important sugarcane- producing regions of China. Guangxi accounts for over 60 per cent of the country's sugarcane planting area, making it vital to China's sugar production. However, growth of the sugarcane industry is challenged by labour shortages and an ageing rural population. Traditional sugarcane farming is still labour-intensive, with each hectare requiring 20 to 30

[3] Intelligent assisted driving systems are a general-purpose technology that integrate information technology such as BeiDou satellite navigation, sensors and automatic control which is the basis for smart agricultural machinery and precision agriculture. These systems can be installed on tractors, combine harvesters and other agricultural machinery, and cost between RMB 20,000 and RMB100,000 per set (approximately $2,800–$14,000).. More than 300,000 of these systems are currently in use across agricultural machinery in China.

Figure 2: Ms. Wei Shuixiu and the sugarcane harvester

workers, particularly during harvesting, further reducing overall production efficiency.

To address these challenges, both national and local governments have prioritized the industrialization of sugarcane production, offering significant subsidies for sugarcane seeds and suitable machinery including specialized equipment for sowing and harvesting. In 2015, Wei Shuixiu transitioned from running a fruit wholesale business to entering the agricultural sector by establishing a sugarcane planting cooperative. She adopted mechanized production by securing operating licenses for combine harvesters and crop protection drones. Today, her cooperative, covering more than 60 hectares, is a model for local farmers and practitioners in the region.

Her case highlights the following aspects of women's empowerment through agricultural mechanization.

(1) Innovative implementation of machine-compatible planting models

In 2015, while nearly 60 per cent of land preparation for sugarcane production was fully mechanized in Guangxi Province, only 39 per cent and 6.5 per cent, respectively, of planting and harvesting operations were mechanized, significantly limiting growth of the sugarcane industry in the region. Full mechanization requires a 'machine-compatible' planting model. Accordingly, Ms. Wei learned the relevant technologies, consulted experts and collaborated with local agricultural government departments of technology. She introduced key innovations in sugarcane planting methods, including improving the level of soil preparation, building machine-accessible infrastructure, selecting mechanization-compatible sugarcane varieties, and optimizing furrow depth, cutting lengths and planting density. Most importantly, she adjusted the planting row spacing from the traditional 0.90 cm to 1.20 cm, enabling the use of large combine harvesters. This adaptation laid the groundwork for the full mechanization of sugarcane cultivation.

(2) Promoting full mechanization and expanding sugarcane plantations

After adopting the 'machine-compatible' sugarcane planting model, Ms. Wei invested in acquiring medium and large tractors, sugarcane planters and the then-novel sugarcane combine harvesters. She also introduced crop protection drones for pest and disease management, replacing the traditional low-efficiency equipment.

With the combined support of sugarcane machinery manufacturers and the local agricultural mechanization technology promotion department, Ms. Wei developed a fully mechanized sugarcane planting process. Fully mechanized sugarcane planting is estimated to save RMB7,500–RMB9,000 (approximately $1,050–$1,250) per hectare annually. Following the successful trial of mechanized planting on 20 hectares in 2015, Ms. Wei had expanded her plantation to over 60 hectares by 2018 with significant economic benefits.

(3) Encouraging neighbouring sugarcane growers to adopt modern practices

In Guangxi, where much of the terrain is hilly and mountainous, sugarcane is mostly cultivated by small-scale farmers. Ms. Wei's innovations in sugarcane mechanization have set a positive example, encouraging nearby farmers to move beyond traditional practices and explore 'machine-compatible' land modifications and planting models.

Moreover, by providing mechanized farming services, Ms. Wei has supported neighbouring small-scale farmers in adopting modern production practices. In 2023, Ms. Wei provided mechanized services for sugarcane planting, crop protection and harvesting over 100 hectares.

C. Case Study III: Female President of Cooperative

Background: Born in the 1980s, Ms. Wang Lijuan leads a large cooperative specializing in grain and oil production in Pukou District, Nanjing, Jiangsu Province in China. Starting with managing her family's 13 hectares of farmland, she obtained a tractor driving license in 2016 to mechanize farming operations and address the shortage of skilled machinery operators. Benefiting from stable grain cultivation and local government support for land transfer and high-standard farmland construction as well as subsidies for the purchase and operation of agricultural machinery, she expanded the

Figure 3: Ms. Wang Lijuan inspects the growth of the crops.

her family farm into a cooperative. Today, the cooperative covers more than 660 hectares and Ms. Wang's role has evolved from agricultural production to cooperative management. Under her leadership, the cooperative is moving towards high-quality full mechanization, standardization, and industrialization.

Her case highlights the following aspects of women's empowerment for sustainable agricultural mechanization.

(1) Transitioning from full mechanization to precision agriculture practice

Ms. Wang's cooperative is transforming rice, wheat, and rapeseed production, moving from full mechanization to precision agriculture, utilizing intelligent equipment technologies and practices such as integrated water and fertilizer systems, agricultural drones and crop monitoring systems.

Suitably located plots that are concentrated, level and easy to irrigate and fertilize are selected for integrated water and fertilizer systems. These automated systems enable precise adjustment of water-fertilizer ratios and spray schedules, optimizing resource use and significantly reducing labour costs. The development and use of crop monitoring devices and systems allows remote observation of crop growth and lodging conditions through computer or mobile devices, facilitating timely intervention to prevent crop damage. Specialized agricultural drones also facilitate regular monitoring of crop diseases and pests, allowing precise fertilization and pesticide application to maintain yield. Precise control of pesticide and fertilizer application, together with scientific management practices, enables the cooperative to consistently produce high-quality rice that is well regarded by consumers.

(2) Expanding grain production to pre- and post-production stages

As the cooperative's cultivation continues to grow, it has expanded its focus beyond the production phase to the pre- and post-production stages, all

based on full mechanization.

The cooperative invested over RMB9 million (approximately US$ 1,250,000) in 2024 in the pre-production stage, to establish a fully automated seedling cultivation centre. Equipped with conveyor belts and robots, the facility is remarkably efficient, processing 2,000 rice seedling trays per hour, compared to just 50 trays per hour manually. The entire process requires only two operators to supply seedlings for 2,600 hectares. Automated temperature and humidity controls ensure consistent seedling quality, enabling the cooperative to provide high-quality seedlings for its own operations and to nearby contracted farmers.

For the post-production stage, the cooperative has built a mechanized drying centre and a grain primary processing centre. These facilities provide grain drying services to surrounding areas and have established a complete grain production chain, enhancing the cooperative's overall efficiency and value addition.

(3) Promoting standardized management and developing the cooperative brand

Ms. Wang introduced strict cost-control measures and strategic marketing initiatives to improve the cooperative's operations. She introduced an "Agricultural Material Consumption List" to track the inflow and outflow of agricultural supplies for materiel management and machinery service operations are monitored with an "Operation Scale Confirmation Form", ensuring task completion and accountability. This standardized management system helps control production costs, enforce responsibilities, and prevent fraudulent practices, fostering efficiency and transparency throughout the cooperative.

The cooperative has registered the 'Mingwen Rice' brand, which has won awards such as "Good Rice of Nanjing" and "Flavor Rice of Jinling", from 2019 to 2021. The cooperative produces approximately 10,000 tons of rice annually, marketed both online and offline, bringing substantial economic benefits to local farmers.

(4) Helping cooperative members and neighbouring smallholders reduce costs and increase income

As the leader of a large cooperative, Ms. Wang prioritizes support to all members to help them achieve higher incomes. She introduced an innovative dual approach for sharing of agricultural machinery. Machinery-owing members can provide rental services to other members at reasonable rates or machinery owned by the cooperative is made available to members needing it. This approach enhances equipment utilization efficiency and eases the financial burden on members who do not own machinery.

The cooperative also standardizes procurement and distribution of agricultural supplies and purchases agricultural products from members. Members benefit from access to machinery and supplies at below-market rates, while the cooperative buys their products at or above market rates, leveraging China's price protection policies for rice and wheat.

This model not only ensures a stable income for members but also allows the cooperative to process and sell branded rice, generating additional revenue. Besides supporting members, the cooperative assists neighbouring small-scale farmers with seedling cultivation, supply, and mechanized services, helping them reduce costs and increase their income.

III. Outcomes of women's empowerment for Sustainable Agricultural Mechanization

A. Addressing labour shortages

The agricultural sector in China faces significant operational challenges due to a growing shortage of labour and an ageing workforce. Data from China's seventh census conducted in 2021 showed that the rural population had decreased by 164.36 million since 2010. Integrating women into the traditionally male-dominated field of agricultural mechanization can help address these challenges.

As demonstrated by the case studies, labour shortages offer opportunities for women to step into key roles traditionally dominated by men. The acquisition of new skills, such as operating advanced machinery like drones, enables women farmers to meet local labour shortages and inspires other women to take up agricultural mechanization. Their participation showcases the potential for innovative technologies to expand access and inclusivity in agriculture.

While a shortage of labour is a significant challenge for the agricultural sector in China and other countries in the Asia-Pacific region, it is also an opportunity for growth and women's empowerment. Encouraging agricultural participation by women and other underrepresented groups can turn this obstacle into a pathway for progress. Stronger legal frameworks and integrated social support systems are crucial for promoting inclusivity, providing a supportive environment and the infrastructure for participation by women and other underrepresented groups in agricultural mechanization. The case studies offer valuable insights to other Asian and Pacific countries facing similar challenges.

B. Standardizing cooperative management

Progress in agricultural modernization requires not only steady improvements in production efficiency but also a transformation of business operations for higher productivity. Empowering women to participate in agricultural mechanization and management decisions can drive the transition to a more standardized operation, as demonstrated by the case studies. The cases show how women's leadership in cooperatives can standardize agricultural management. By implementing cost-control measures and introducing tools to monitor resource use and track operation progress, farms can effectively optimize resource use minimize waste, and ensure accountability.

Amid fluctuations in the prices of agricultural inputs and products, women's active participation in decision-making can ensure resilience and improve profitability.

C. Enhancing smart agriculture innovations

Women can play a pivotal role in smart agriculture through the adoption of innovative technologies promoting efficiency and automation. As demonstrated by the case studies, tools such as agricultural drones for crop protection, seeding and fertilization are transforming farming practices by reducing the demand for physical labour and increasing precision. Using smart technologies, women have streamlined critical farming tasks, minimized exposure to chemical and optimized resource use. Their active engagement with such innovations demonstrates how smart agriculture can address practical farming challenges while advancing sustainability and productivity.

Providing women with access to training, certification and resources for smart agricultural technologies can amplify the impact of such technologies. As the case studies show, women's engagement with and promotion of advanced machinery fosters their widespread adoption, inspires innovation, and accelerates agricultural modernization. Strengthening women's participation in smart agriculture is essential to reshape farming and promote sustainable agricultural development.

D. Promoting green agricultural practices

The rapidly increasing adoption of green agricultural practices is being driven by innovative, sustainability-promoting technologies. As demonstrated by the case studies, drones can minimize chemical use during pesticide application, reducing adverse environmental impact and preserving productivity. Mechanized planting techniques and optimized planting models conserve resources, improve soil health and reduce labour intensity, particularly in resource-intensive crops like sugarcane. These advancements in environmentally responsible farming methods reduce water, fertilizer and pesticide use while supporting long-term agricultural sustainability.

Widespread adoption of such eco-friendly practices is essential for reducing agriculture's environmental footprint. Empowering women farmers to lead the transition toward greener agricultural practices will drive innovation and ensure a more sustainable future for agriculture.

IV. Challenges for women in agricultural mechanization

A. Public scepticism

The use of agricultural machinery is still commonly associated with physical strength and technical expertise, traditionally seen as male attributes. Such perceptions result in scepticism of women's ability to operate farm equipment like tractors, harvesters, and drones. The women farmers in the case studies often faced doubts about their skills and the quality of their work. Women often need to demonstrate their competence repeatedly, having to invest significant time and effort to gain the trust and respect of male peers and communities. Their determination and success underscore the need for broader societal recognition of women's capabilities in agriculture mechanization, challenging outdated stereotypes and paving the way for greater inclusion.

B. Family pressure

Women in many countries in the Asia-Pacific region are increasingly taking on new roles in agricultural production, especially as men migrate to urban areas for work. However, this shift often presents a dual challenge: balancing agricultural responsibilities with traditional household and caregiving expectations. Historically, women have served as primary caregivers. As women take on agricultural mechanization roles traditionally assumed by men, they may encounter resistance from family members who uphold traditional gender roles. Empowering women for participation in agricultural mechanization requires more than just skill-building. It involves fostering a supportive environment where families, particularly elders, understand and respect these evolving roles. As highlighted by the case studies, creating awareness within families and communities – particularly among elders – about the importance of women's contribution in agriculture is essential. Such support can alleviate the pressures women face, empowering them to excel in their dual roles as caregivers and agricultural innovators.

C. Machinery- and technology-related challenges

Traditional manual-operated machinery, requiring significant physical strength and technical skill to operate, is generally used in areas with relatively underdeveloped agricultural infrastructure and this creates barriers to efficiency and inclusivity. Although technological advancements have made farming equipment more user-friendly, many machines still lack modern features such as continuously variable transmission (CVT) technology and comfortable, enclosed cabins with

air conditioning. These limitations can make the work environment uncomfortable particularly when operators have to face wind, dust, diesel exhaust, extreme weather conditions and physical strain.

While these technological limitations affect all operators regardless of gender, the impact is disproportionate on those with limited access and training opportunities. Women in agriculture often face additional barriers to accessing the latest equipment or training, which can hinder their efficiency and productivity.

However, as shown by the case studies, women can overcome these challenges, demonstrating resilience and adaptability. By acquiring the skills needed to operate various types of machinery, they have not only navigated the difficulties posed by limitations of existing equipment but also generated demand for improved designs that prioritize inclusivity and usability. These successes highlight the importance of training and capacity-building opportunities to ensure that all operators, regardless of gender, can fully contribute to advancing agricultural technology and practices.

D. Machine operating environment

Operating agricultural machinery in challenging terrain such as hills and mountains, or under extreme weather conditions like intense sunlight, freezing temperatures and heavy rain, poses significant challenges for operators. While technological advancements have reduced the physical demands of operating agricultural machinery, busy farming seasons can still require long hours of continuous work over several days. Even experienced agricultural machinery operators often have to contend with exposure to dirt, heat and other challenging conditions.

The case studies demonstrate the importance of skill development, adaptability and persistence in overcoming these environmental challenges. For instance, their ability to operate advanced machinery, such as drones and combine harvesters, while navigating extreme conditions, underscores the value of targeted training and capacity-building.

Therefore, empowering women for agricultural mechanization requires more than just equipping them with technical skills. It also involves creating an environment that prioritizes their well-being. Enhanced training support, access to modern equipment and recognition of their contribution is essential to ensure that operators, regardless of their role or background, are prepared to excel in these challenging conditions.

V. Recommendations

Although China has made significant progress in agricultural mechanization, challenges persist in achieving gender inclusion within the sector. Despite constitutional commitments to gender equality and legal guarantees of equal pay for equal work, traditional beliefs and structural barriers continue to hinder women's full participation in agricultural mechanization. These include limited access to advanced technologies, societal expectations and insufficient targeted support for women in mechanized farming. These barriers are not unique to China and women in agriculture across the Asia-Pacific region, encounter similar challenges, which are often more severe in less developed areas where infrastructure and institutional support are limited. Addressing these obstacles is crucial not only for promoting gender equality but also for driving sustainable agricultural growth and rural development.

The following recommendations are tailored to the Chinese context but may also be relevant for other countries in the region. By addressing structural barriers, enhancing access to resources and technologies, and promoting supportive policies, these measures aim to empower women and strengthen their participation in agricultural mechanization. Implementation of these recommendations will promote a more inclusive and sustainable future for agriculture both in China and across the Asia-Pacific region.

(1) Support and empower women in Sustainable Agricultural Mechanization

As women increasingly assume roles as machinery operators, professional service providers and decision makers in agricultural production, it is crucial for governments and society to acknowledge and support their contribution. Policies should explicitly encourage women's participation in agricultural mechanization teams and professional networks. This includes ensuring equal pay, eliminating social discrimination and promoting women's decision-making autonomy. Recognition of women's vital role in addressing labour shortages and driving technological and green transformation in agriculture will strengthen their contribution to sustainable development.

(2) Enhance research and development of women-friendly agricultural machinery

The design and development of agricultural machinery should prioritize user-friendliness, ergonomics and safety to better accommodate diverse operators, with particular attention to women. Enclosed cabins with air conditioning, automated controls and digitally operated systems can improve operational ease and safety.

Green and smart technologies can also reduce physical demands and enhance efficiency, enabling broader participation by women in agricultural mechanization. Progressive improvements in farmland infrastructure will enhance machinery accessibility, creating favourable conditions for women to work in agricultural production.

(3) Expand education and training for women to develop professional skills

Expanding access to education and training programmes for women is critical for the professional development of agricultural mechanization. Removing barriers to participation, such as cultural biases and logistical challenges, is essential. These can be addressed through training

quotas for women, creating databases of female machinery operators and specialized training courses in machinery operation, agricultural management and safe practices.

Accessibility can be increased by governments and organizations providing training through diverse channels such as online courses, instructional videos and community-based workshops. Mass media broadcasts can also raise awareness of women's contribution to agriculture. Local governments can play a role by organizing operational teams with female participation, identifying demand for and the supply of mechanization services and creating employment opportunities, recognizing women contribution to the sector. All these actions can build a more inclusive environment for women to participate in agricultural mechanization and foster long-term skills-development and empowerment.

(4) Strengthen the legal framework to better protect women's rights in agricultural mechanization

There is a need to establish and enforce a legal and regulatory system that protects women's rights in agriculture, ensuring equal access to agricultural mechanization. This includes enforcing anti-discrimination policies, guaranteeing fair pay and providing oversight for safe and equitable working conditions. Legal frameworks should also promote community awareness through media campaigns that highlight gender equity in agricultural mechanization and the importance of women's contribution to the sector.

(5) Develop comprehensive social support systems for women in agricultural mechanization

Recognizing and addressing the dual roles of women in agriculture and family care is vital. Advocacy of family-friendly policies, provision of childcare support and flexible working conditions can help women manage both professional and personal responsibilities. Community and family support programmes should foster awareness of the importance of women's participation in agricultural mechanization, reducing societal barriers and enhancing their capacity to contribute.

Empowering women for agricultural mechanization not only promotes gender equality but also sustainable agricultural growth, rural development and food security. The recommendations outlined in this paper seek to address structural barriers, expand access to modern technologies and foster inclusive policies that enable women to fully engage in and contribute to agricultural transformation. As demonstrated by the case studies, women's active engagement in agricultural mechanization can drive innovation, improve productivity and set a benchmark for broader societal progress. By investing in promoting women's skills, rights and opportunities, policymakers and stakeholders can ensure that agricultural mechanization becomes a catalyst for both gender inclusion and sustainable development in China and across the Asia-Pacific region.

References

CAI, Hong, and HUANG Li (2017). What is Feminization of Agriculture: Discussion and Reflection. *Journal of Agro-Forestry Economics and Management*, (5): 652-659.

Food and Agriculture Organization of the United Nations (2011). *The State of Food and Agriculture (2010-11)*. Rome.

Food and Agriculture Organization of the United Nations (2023). *The Status of Women in Agrifood Systems - Overview.* Rome.

HU, Yukun (2009). The "Three Rural Issues" Crisis and Gender Issues in China During the Transitional Period: An Exploration Based on the Perspective of Globalization. *Journal of Tisinghua University (Philosophy and Social Sciences),* (6): 54-69, 158-159.

JIANG Yan, LI Meng, PAN Lu (2021). Becoming Young Female Farmers: The Process and Characteristics of Rural Women Engaged in Family Farming[J]. *Journal of China Agriculture University (Social Sciences)*, 38(2):73-81.

MENG, Xianfan (1993). Chinese Rural Women in Rural Labor Migration. *Social Science Front,* (4):147-154.

Rural section, Ministry of Women Development, Women's Federation of China (2015). To cultivate New Female Professional Farmers and Promote the Development of Modern Agriculture: Reflections on the Education of New Female Professional Farmers in the New Situation. *Chinese Women's Movement*, (4): 21-24.

World Bank Group (2024). *Women, Business and The Law*. Washington, D.C.

Word Health Organization (2023). Progress on household drinking-water, sanitation, and hygiene 2000-2022: *Special focus on gender*. Geneva.

ZHANG, Zhixin, LI Cheng, and JIN Yue (2021). Aging and Feminization of Rural Labor Force and Food Supply Security. *Agricultural Economy Management,* 35(1): 86-96.

YUAN, Xin, and LIU Houlian (2015). A Study on the Migration of Agricultural Labor Force After 1978: Based on the Population Censuses of China. *Journal of China Agricultural University (Social Sciences)*,（4): 76-83.

ZHANG, Zhixin, LI Cheng, and JIN Yue (2021). Aging and Feminization of Rural Labor Force and Food Supply Security. Agricultural Economy Management, 35 (1): 86-96.

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