ESCAP | CSAM
Centre for Sustainable Agricultural Mechanization

Research Progress and Trends of Agricultural Machinery in Hilly and Mountainous Areas

Haoming Wu
Deputy Secretary of the Party Committee, Southwest University

Eleventh Regional Forum on Sustainable Agricultural Mechanization
Climate-smart Agricultural Mechanization for Sustainable Crop Residue Management and Resilient Agrifood Systems
26-28 October 2026 – Tianjin, China

Part 1: Agricultural Mechanization Status in China's Hilly and Mountainous Areas

①Terrain： Small, Sloped, Fragmented Fields

- Nationwide, hilly and mountainous areas account for roughly one-third of the total arable land.
- Fields are small, fragmented, and markedly uneven, with elevation differences between adjacent plots exceeding 1 meter.

②Labor： Rural Labor Exodus

- Massive out-migration: young and middle-aged men are leaving farming to seek employment elsewhere, and the agricultural workforce continues to shrink.

③Female Dominance in Left-Behind Farm Labor

- As men migrate out for work, the share of women among those remaining in agriculture rises significantly, making women the primary labor force in field operations.

④Aging: "Replacing Labor with Machines" Has Become Essential

- Those remaining in farming are predominantly middle-aged and elderly, with visibly declining physical strength. Traditional manual labor, such as carrying loads on shoulders and backs, is no longer sustainable.



Terrain: Small, Sloped, Fragmented Fields



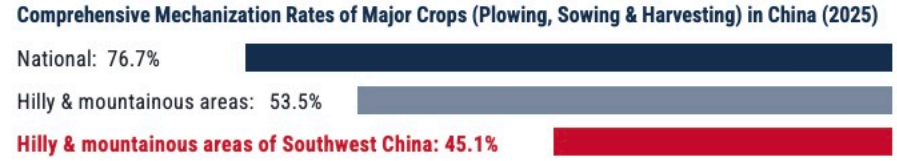
Labor: Rural Labor Exodus



Female Dominance



Aging Workforce



Part 1: Agricultural Mechanization Status in China's Hilly and Mountainous Areas

Policy Support:







Full-process mechanization for staple crops is technically feasible, but lacks suitable machinery.



Large tractors struggle to turn and easily roll over on steep slopes.



Large transplanters get stuck in deep-mud paddies.



Lack of suitable machinery leads to widespread land abandonment.

Mechanization by Major Grain and Oil Crops

Rice	90.13%	Mechanical transplanting and direct seeding
Corn	92.64%	Mechanical sowing and harvesting lag markedly
Potato	62.45%	Mechanical planting and harvesting: the two weak links
Rapeseed	72.88%	Direct seeding and combine harvesting

Staple crops: Transitioning from "no machines" to "needing better machines".

Specialty Cash Crops: No Machines Available

Core production zone for specialty crops.

Case studies: Fengjie, Fuling, Wushan (Chongqing).



Fengjie Navel Orange

Pest control, picking, and transport rely on manual labor.



Fuling tumorous stem mustard

No suitable machinery for sowing and harvesting



Wushan Crisp Plum

Manual labor only



Tobacco Leaf

No suitable machines for transplanting or harvesting

Common pain points: Sloped land, smallholders, and irregular spacing limit general-purpose machinery. "No machines available" is a harder challenge than "hard-to-use machines".

Policy support: MARA programmes demonstrating and extending full-process mechanization for specialty crops; local pilot demonstrations, such as Chongqing's "one county, one industry" mechanization pilots.

Specialty Cash crops: Stuck at "no machines available" — the final frontier.

Part 2: Research Progress at Southwest University

2.1 Full-Process Mechanization of Staple crops

Objective: Address the "no good machine available" problem and achieve machinery–agronomy integration.

Rice: transplanter for deep-mud paddy fields (eliminates sinking)





Rice: Unmanned combine harvester





Soybean–corn strip-intercropping seeder



Corn harvester for hilly and mountainous terrain



Potato seeder



Potato combine harvester (suited to heavy, sticky soils)

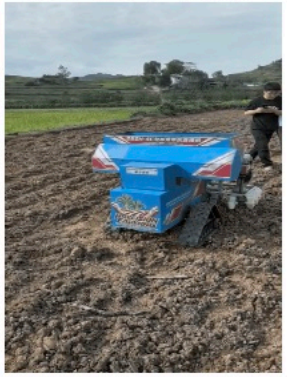


Part 2: Research Progress at Southwest University

2.2 Breaking the "No Machine Available" Barrier for Specialty Cash Crops

Objective: Develop dedicated, compact smart equipment for the specialty crops of Southwest China.

Ash-coated seeder for tuber mustard



Vegetable transplanter



Autonomous variable-rate orchard sprayer



Compact self-propelled soybean harvester





Intelligent citrus picking robot







Machine-vision autonomous weeder



Canopy-guided zoned fertilizer applicator



Flue-cured tobacco leaf harvester & loader

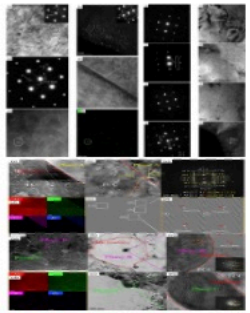




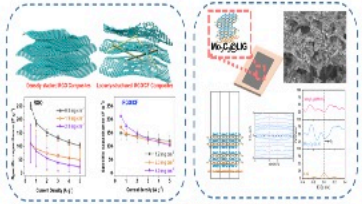
Part 2: Research Progress at Southwest University
2.3 Breakthroughs in Key Enabling Technologies

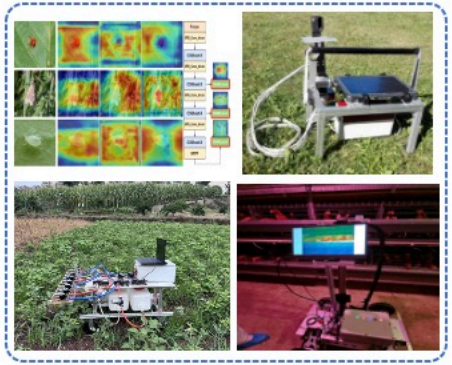
Lightweight Materials: Solid-state joining & additive manufacturing





Intelligent Sensing: Self-powered sensors across the crop lifecycle





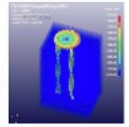
Drag Reduction: Bio-inspired anti-adhesion technology for soil-engaging components





Drag Reduction: Dual vertical-shaft rotary tillage





Spiral blade & simulation





Vertical blade





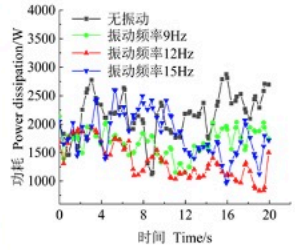
Horizontal plow blade



Performance test

Drag and energy reduction in subsoiling based on vibration-assisted cutting





Part 2: Research Progress at Southwest University
2.4 Autonomous Operation and Smart Farming

Core technologies: Adaptive Path Planning & Multi-machine Collaborative Scheduling

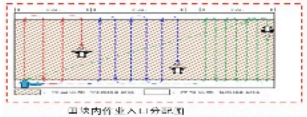
Adaptive path-planning for field operations

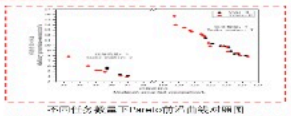


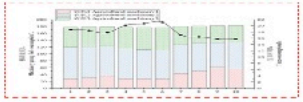
Multi-machine task allocation for subsoiling operations

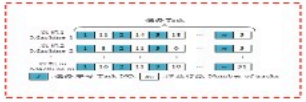


Multi-machine Collaborative Task Allocation



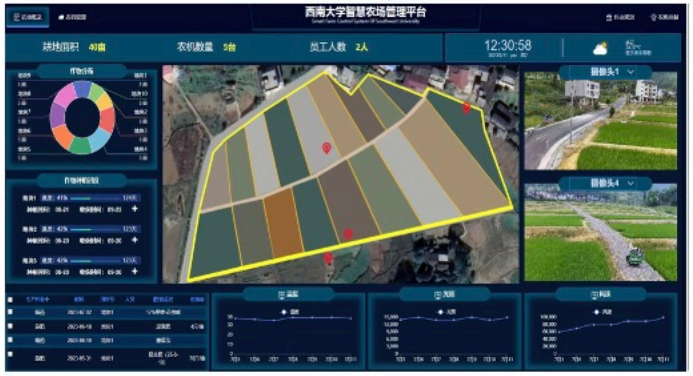






Demonstration: SWU Smart Farm Management Platform (Chongqing； Nepal)

Real-time monitoring dashboard











Part 3 Development Trends

Intelligent Equipment · Climate-Smart Production · Green Utilization

01 Technology & Equipment

- Foundation: Lightweight
- Direction: Intelligent & Integrated

· Compact, lightweight, intelligent, multi-functional

· Tracked / articulated / slope-adaptive chassis

· Combined tillage–seeding–fertilizing–residue implements

· Electric micro-machinery for short, scattered field work

· From technology breakthroughs to full mechanization

Ecosystem | Clustered regional collaboration



02 Climate Intelligence

From nature-dependent to climate-smart production

Sense | Micro-climate stations, soil/crop sensors and UAVs
→ integrated space–air–ground monitoring

Decide | Weather big data, crop models and AI
→ variable-rate operations & hazard alerts

Action | Beidou guidance, UAV spraying and integrated water–fertilizer → alerts trigger operations

Priority Climate-smart equipment for labor-saving in mountainous areas.



03 Green Production

Conservation & Circularity: Residue return, removal and utilization

Return | Lightweight chopping & no-till mulching
→ moisture retention & erosion control

Remove | Balers, pickup-loaders, and mountain rail systems for efficient transport

Goal | Soil and water conservation & erosion control

Utilize Convert residue to fertilizer, feed, fuel, or substrate
→ high-value circular use



This page contains AI content

THANK YOU

No farmer left behind on the road to mechanization.

SOUTHWEST UNIVERSITY

Tel:+86 023-68251060
Email: wuhaoming@swu.edu.cn
Website:www.swu.edu.cn

ESCAP | CSAM
Centre for Sustainable Agricultural Mechanization