

grain quality is protected from seedling cultivation to post-harvest handling (Table 1). In the Mashan case, the service center does not function as a loose collection of separate services, but as an integrated chain in which field timing, machine scheduling, seedling quality, drying capacity, and technical guidance support one another.

Table 1 Full-process mechanization chain in high-quality rice production

Link	Main practice at Mashan	Main contribution
Centralized seedling cultivation	Unified nursery preparation and tray seedling supply	More uniform seedlings and lower household labor demand
Mechanized transplanting	Timely transplanting through service teams	Reduced labor bottlenecks and more standardized planting
Mechanized field management	Organized water, fertilizer, and technical guidance	Easier adoption of standardized management
Green plant protection	Scaled plant protection and technical support	Lower missed-control risk and more targeted pest management
Combine harvesting	Rapid harvester dispatch during peak season	Better timeliness and lower field losses
Grain drying and processing	Centralized drying, storage, and rice processing	Lower postharvest loss and better quality retention

This framework is consistent with recent studies on rice mechanization, which increasingly emphasize that labor saving alone is not enough. Seedling supply, service accessibility, harvest timing, drying control, and postharvest organization are all important in determining whether mechanization can improve rice production in a stable and environmentally reasonable way (Liu and Li, 2023; Li et al., 2024; Ruan et al., 2025).

### 3.1 Mechanized application of centralized rice seedling cultivation

Centralized seedling cultivation is the first key threshold in many machine-transplanted rice systems. If seedlings are weak, uneven, or not available on time, later mechanized operations lose part of their value. Recent research on machinery rice transplanting and centralized rice seedling cultivation in China shows that modern seedling centers do more than save labor. They improve seedling supply efficiency, raise the use efficiency of nursery space, and make large-scale machine transplanting easier to organize (Ruan et al., 2025).

The Mashan materials show this logic clearly. The center includes a dedicated seedling cultivation area and provides more than 200,000 trays of early- and late-rice seedlings annually for local farmers. The project materials also report that technical guidance associated with the center helped improve seedling establishment rates for surrounding farmers by about 20%. Although these figures are operational records rather than controlled experimental data, they still show a practical point: standardized seedlings are one of the most direct ways to improve later field performance.

This stage also has a green-production meaning. Centralized seedling cultivation can reduce repeated household-level preparation, lower waste in nursery materials, and make seed treatment and early-stage management easier to standardize. More importantly, it creates the basic condition for timely transplanting. Delayed or uneven transplanting often leads to uneven tillering, uneven maturity, and later problems in water control, pest prevention, and harvesting. By contrast, centralized seedling supply supports more synchronized crop growth, which is especially valuable in quality-oriented rice production.

### 3.2 Mechanized rice transplanting and field management

Mechanized transplanting is one of the most visible signs of modern rice production in eastern China, but it should be understood as a service system rather than only a machine operation. Shangyu's local policy documents in 2024 clearly aimed to improve the local machine-transplanting rate through targeted subsidy support, indicating that machine transplanting is not only a farm-level choice but also a district-level policy priority.

In the Mashan case, machine transplanting is embedded in organized service delivery. The center's mechanized operation teams provide field services across nearby and broader regional rice areas, reducing the need for farmers to coordinate seedling transport, machine booking, and field labor by themselves. The practical gain is not only