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The Power of Organization: A Revitalized Trusteeship Model for Food Security and Poverty Eradication - Insights from Shanxi Agricultural Innovation

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Abstract: Our goal is to advance agricultural mechanization and scaling, even in mountainous and hilly regions worldwide. This paper presents an innovative approach to optimizing the agricultural production trusteeship mechanism, drawing from field research in Shanxi Province. Specifically, we seek to refine and adapt China's agricultural trusteeship model for developing countries, particularly those along the Belt and Road, in a context-sensitive manner. By strengthening food security and economic benefits, this model directly contributes to No Poverty and Zero Hunger. Using China as a case study, we first examine the evolution of agricultural scaling operations, analyzing both its necessity and existing challenges. We then propose a revitalized trusteeship model based on field studies in Shanxi Province. Finally, we evaluate the feasibility of implementing this model globally in regions facing poverty and food insecurity.

Keywords: Food Security; Poverty Alleviation; Agricultural Production Trusteeship

1. Introduction

1.1 China's new problem of agricultural development

For those developing countries worldwide, including China, we have to confront and resolve the waning reality when sighting the agriculture: who will farm the land?

Since reform and opening-up, the integration of urban-rural dual economic system and socialist market economic system has given our country a number of impressive contributions in economy development. Of them, rural revolutions, including household contract responsibility system, even liberate productivity in the ever-huge extent, solving the starving and food increasing problem (Cai,

2016). Whereas the prosperous situation continuously exists, the high-paced process of industrialization and urbanization leads to the worsening problems in agricultural area, with represented by the huge transfer of young and middle-aged labor force, the severe lack of manpower in busy farming season, the concerning aging and the growing agricultural multiple job-holding and sidelining.

The urbanization rate of China's permanent population rose from 17.92% in 1978 to 64.72% in 2021, while the proportion of employed people in the primary industry fell from 70.53% to 22.87%. According to the data of The Third National Population Census, in 2020, the proportion of the elderly people aged 60 and over in the total rural population in China's rural areas was 23.81%, and those aged 65 and over was 17.72%. And to be more convincing, Shanxi Province, where our key research implemented, has met the ever-serious labor force loss in recent 10 years (seen as in **Table 1** below). There's no doubt that the structural lack of agricultural labor force has become increasingly serious.

Table 1: Comparison of the number of permanent residents in cities of Shanxi Province in the Seventh Population Census

regions	2020 (million people)	2010 (million people)	population growth+ population decrease- (thousand people)	percentage (%) 2020	percentage (%) 2010
total	34.92	35.71	-796.5	100	100
Taiyuan	5.3	4.2	1102.5	15.19	11.77
Datong	3.1	3.32	-212.5	8.89	9.29
Yangquan	1.32	1.37	-50	3.78	3.83
Changzhi	3.18	3.33	-153.7	9.11	9.34
Jincheng	2.19	2.28	-84.6	6.29	6.38
Shuozhou	1.59	1.71	-121.4	4.56	4.8
Jinzhong	3.38	3.25	130.1	9.68	9.1
Yuncheng	4.77	5.13	-360.3	13.67	14.38
Yizhou	2.69	3.07	-377.8	7.7	8.59
Linfen	3.98	4.32	-340.1	11.39	12.09
Luhliang	3.4	3.73	-328.6	9.73	10.44

Source: The Third National Population Census

1.2 Key solutions: mechanization & scaling

Over ten years of deepening agricultural development, we have summed up some significant characteristics: mechanization, scaling, improved varieties, greening, etc., which all aim to stimulate the efficiency without the increase of manpower. Among them, mechanization and scaling stand out to be the two promising tendencies. Mechanization fundamentally solves the current situation of low production efficiency of agricultural labor force by transforming the agricultural relying centre from manpower and animal power to mechanical power. Agricultural mechanization and scaling predominate the contemporary agricultural productivity, which is the key to improve the sustainable development of China's agriculture. Consequently, the burst of related productivity inevitably accelerates the revolution of production relations, including the agricultural management mode. By organizing farming individuals to become large-scale and intensive groups, we may realize the concrete agricultural modernization and better solving the problems of food security and poverty.

1.3 Rationale for agricultural production trusteeship mechanism

Low efficiency of the traditional land circulation management and dual decentralization of farmland and property rights hamper the international popularization of agricultural mechanism and scaling.

Whereas we have gained world-famous achievements of popularizing agricultural mechanism and scaling, China also encounters the problems below in recent years: first, for the vast plain areas where have conducted scaling, the traditional land circulation management efficiency reveals to be low; Second, for mountainous and hilly areas with nearly one-third of China's agricultural land, the geographic fragmentation and the decentralization of property rights both hamper the process. Therefore, how to better promote appropriate agricultural scaling operation and lead individual farmers into the modern development track of agriculture has become an action spree in recent years.

As one of the most important grain producing areas of China, Shanxi Province continuously holds its international fame thanks to its prestigious vinegar which mainly origins from grain crops, suggesting its representative agricultural lands. Its agricultural technology also stands out, as The Codonopsis pilosula cultivation system in Changzhi County, and Astragalus cultivation system in Hunyuan County were just selected into the preliminary list of Global Important Agricultural Heritage Systems (GIAHS) in 2025.

In this regard, based on thorough research in Hunyuan County in Shanxi, we found that agricultural production trusteeship mechanism, known as one of the representative forms of service scale, possess the ability to achieve compatibility between property rights stability and technological innovation, and to resiliently adapt to different geographical features, no matter plain or hilly areas. It has been verified by us as an effective way to solve the problem of "who will farm the land" and, through on-site research, we further optimized and expanded this potential mechanism, and advocate the "Revitalized Trusteeship Model".

1.4 Significance of trusteeship implementing

Our plan undoubtedly pioneer the global process of large-scale agricultural services and promote world development with the overall view of a community with a shared future of mankind with the selfless attitude of sharing the fruits for human prosperity.

The proposal provide reproducible food security and poverty eradication solutions for developing countries. The 2023 Global Food Security Index shows that China's agricultural total factor productivity has increased by 28% compared to 2015, contributing institutional innovation samples to global agricultural modernization.

Thus for our country it promotes the process of agricultural mechanization and large-scale development, further liberating China's agricultural productivity and deepening the consolidation of China's achievements in poverty eradication and food security. And by fully implementing our optimized agricultural production trusteeship mechanism, we have actually made an prudent effort to answer the ultimate appearance of agricultural modernization: on the production side, the yield of crops

has greatly increased, the output mode has become highly sustainable, the agricultural production cost is relatively the lowest, and the operation of service organizations or companies is relatively the most stable; On the industrial chain, the additional value of agricultural products has greatly increased, the multi-industry integration has been constructed surrounding the agriculture as the core; On the consumer side, farmers maximize their relative profits, consumers' purchasing power and enthusiasm for agricultural products are greatly improved, and market research is closely aligned with actual production ever-dynamically.

2. Problem Analysis

2.1 Fundamental realities of Chinese agriculture

"Small-scale farming in a large country" is the shared reality of many regions worldwide where farmers are too many and land too little. China occupies just 8% of the world's arable land while supporting 20% of its population. According to the Ministry of Agriculture and Rural Affairs, in 2022 the cultivated land under household contract management averaged only 0.474 hectare per household—far below the internationally recognized smallholder standard of 2 hectares—constituting an "ultra-small scale" pattern (see Table 2).

Table 2 Changes in the proportion of farmers by different acreage scales from 1996 to 2023

farmers' scale of operation (hectare)	proportion of these farmers in 1996 (%)	proportion of these farmers in 2011 (%)	proportion of these farmers in 2015 (%)	proportion of these farmers in 2023 (%)
<0.67	76	86	85.74	91.2
0.67-2	20.2	10.7	10.32	6.51
2-3.33	2.3	2.3	2.6	1.8
>3.33	1.5	1	1.33	0.49

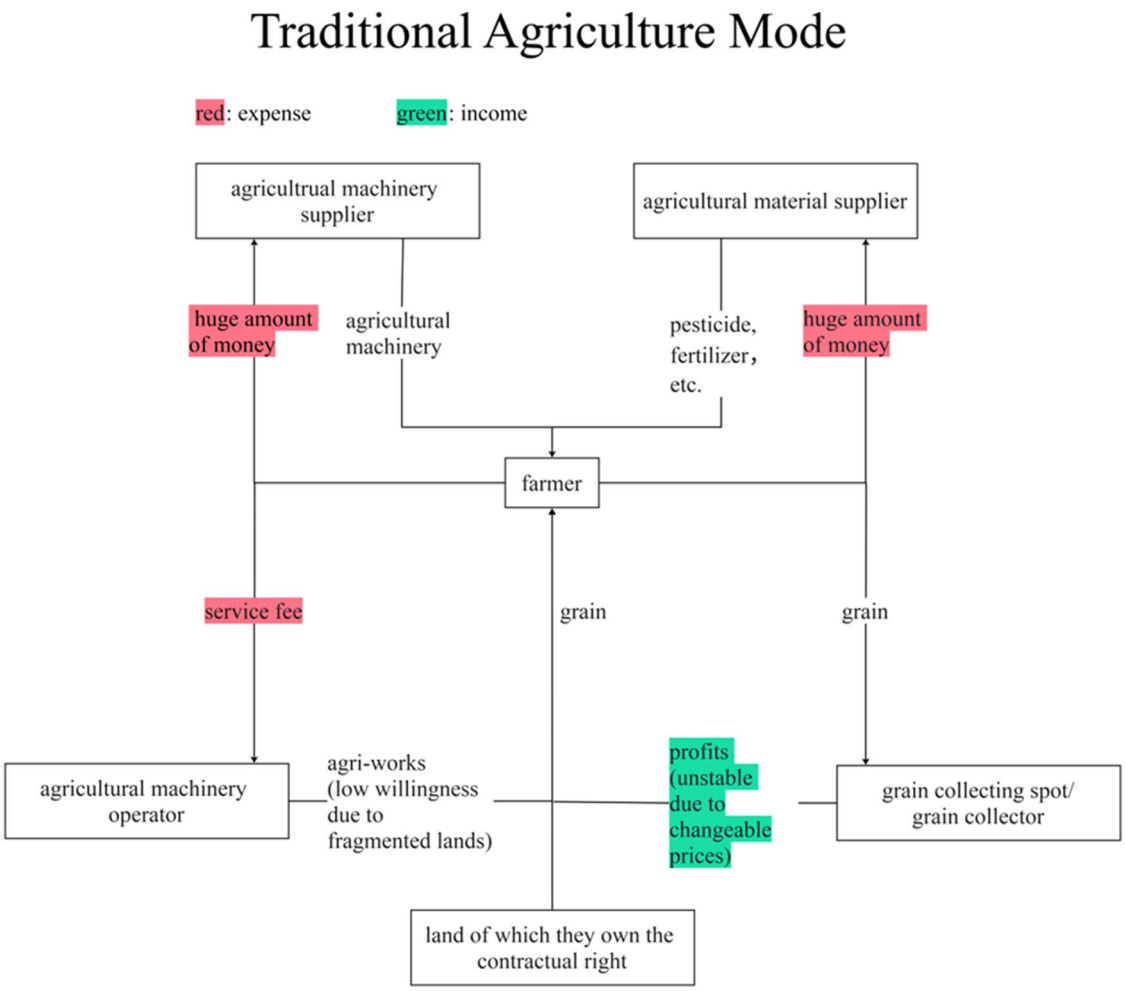
Source: Adapted from "Mechanism of Chinese farmers' land rental participation," by J. Zhang, A. K. Mishra, and X. Ma, 2023, Food Policy, 117, Table 2.

This fragmented mode, colliding with the loss of agricultural labor caused by rapid urbanization, has produced three dilemmas:

1. **Production dilemma**: Land abandonment rose to 11.3% in 2023, and the prevalence of "nobody-planting" and "part-time planting" has stalled growth in per-unit-area yields.
2. **Efficiency dilemma**: China's agricultural scientific and technological progress rate stands at only 58.3%, alarmingly lower than that of developed countries, with total factor productivity also remaining low.
3. **Development dilemma**: Rural hollowing-out and weak collective engagement directly raise the risk of poverty.

Compounding these issues, the traditional agricultural mode (see Figure 2) shows expenses outpacing income. Individual farmers, with weak bargaining power, must pay heavily for machinery and inputs such as pesticides and fertilizers, plus additional fees to professional operators. After harvest, lacking alternative sales channels, they sell to individual grain collection sites and bear substantial market risks from price volatility and information asymmetry.

Figure 1 Traditional agriculture mode



In response, the 2024 Central Number 1 Document underscores national food security, prevention of large-scale returns to poverty, and accelerated agricultural modernization through technological and systemic reforms—measures equally relevant to other nations transitioning from agriculture-based to diversified industrial structures.

2.2 Necessity of moderate-scale operations

As land fragmentation continues to constrain production and livelihoods, moderate-scale operations have become essential for modernization. Two paths have emerged in China: **land-scale operations**, where farmers transfer management rights for concentrated farming, and **service-oriented scale operations**, where farmers retain management rights but outsource specific production processes.

Land transfer has now reached a bottleneck due to high transfer costs and farmers' reluctance to relinquish land.

The traditional farmland scaling theory (Zhou, 2003; Wan and Cheng, 2001) cannot fully resolve fragmented land management. By contrast, the labor division theory grounded in Smith's (1776) and Young's (1928) theorems proves more convincing under today's service-economy orientation (Luo, 2017): under the household contract responsibility system, the alienation of production capacity drives land transfer and scaling, but as scale expands, structural contradictions between household capacity and service demand—coupled with hidden transaction costs—make purchasing large-scale productive services more competitive than expanding land operations.

Our field research in Hunyuan County, Datong, reveals four characteristics of smallholder service demanders: (1) **high multiple job-holding**, driven by rural-urban labor transfer, aging, and feminization of farming; (2) **low livelihood capital**, especially in financial, human, and social dimensions; (3) **strong risk aversion**, with safety as the top priority; and (4) **deep traditional farming attachment**, which sustains agricultural civilization but reinforces the "one hectare, three-part land" complex. These traits collectively signal a strong need for diversified, modern agricultural services.

2.3 Challenges in direct smallholder–provider interface

Service providers face significant challenges when serving dispersed smallholders, owing to limited land scale, capital constraints, underdeveloped markets, and elevated service costs (Ma et al., 2018). Fragmented farmland and diverse demands complicate mechanized operations, raise time costs, and reduce machinery utilization. Transaction costs remain persistently high in information collection, contract negotiation, and supervision. Meanwhile, smallholders' limited capacity creates default risks and revenue volatility, ultimately compressing profit margins and dampening rational providers' willingness to serve them (Wang et al., 2016).

2.4 Dual-organization and integrated collaboration

A seamless connection between farmers and service suppliers is therefore crucial. The **dual-organization model**—operating between individual farmers and service subjects—serves as the linchpin for aggregating "small" into "big."

From the demand side, organizing farmers fulfills service needs more effectively. Integrating fragmented land and unifying planting varieties enable unified machinery operations, reduce movement, enhance efficiency, and cut machine wear. Organized farmers also wield stronger bargaining power and reduce transaction uncertainties for providers in target search, price negotiation, and supervision.

From the supply side, integration among providers enhances service capacity. Cooperation transforms competition into collaboration, pools machinery, personnel, and funds, and supports diversification and scale expansion. Linking upstream and downstream actors builds production–supply–sales channels, expands service radius, and improves efficiency.

Who can realize this idealized dual-organization? Two candidates emerge. *Village collectives*, leveraging human resources, rural social capital, and cultural ties, can promote organization through non-coercive forces such as kinship and reputation, thereby reducing both organizational and transaction costs—though weak economic capacity, limited coordination, and insufficient endogenous motivation often constrain sustainability. *Administrative power* also matters: the central government issues guidance, county governments pilot, and townships implement; this coordination drives participation and integrates funding, but its effectiveness depends on township attention and is limited by departmental fragmentation and leadership turnover.

Relying solely on farmers and providers—or even on collectives or governments alone—is insufficient. The solution lies in coordinating all four actors and building a mechanism that maximizes benefit-sharing and risk-sharing. Under this advanced model, village collective economic organizations organize, mobilize, supervise, and restrain, while the government provides top-level design and standard guidance, delivering an efficient market, a proactive government, and organic governance with Chinese characteristics—stable, institutionalized, and scalable. Built on the effective organization of smallholders, organic cooperation among service providers leverages factor-aggregation scale advantages to reduce costs, raise efficiency, and achieve economies of scale. Our team regards this governance model as innovative and generalizable, and proposes further exploring its optimized operational mechanism to construct a theoretical framework that maximizes shared benefits for all parties.

3. Scheme design

Amidst the wave of promoting agricultural trusteeship across China, Shanxi province's trusteeship practice has been at the forefront of the movement. In 2021, the standing committee of the Shanxi National People's Congress passed the Shanxi Agricultural Trusteeship Service Regulations, elevating the province's trusteeship policy to the level of provincial regional regulation. Subsequently, multiple cities in Shanxi introduced regulations favorable for agricultural trusteeship industry.

3.1 Hengxing Model

With strengthened policy support, a number of agricultural trusteeship service organizations with advanced trusteeship models and strong scale effects have emerged. In Datong City, where our group conducted our field research, the practice of the trusteeship model of Shanxi Hengxing Agricultural Science and Technology Development Co., Ltd. can provide a good reference (**seen as in Table 3 below**). Founded in 2017, the company focuses on agricultural production trusteeship services and feed production. In its business practice, Hengxing has formed a unique trusteeship model - "Hengxing Model" (**seen as in Table 3 below**). It has multiple highlights.

Table 3 Analysis of cost saving and efficiency increase before and after trusteeship

	cost savings (yuan)	efficiency increase	

	agricultural material purchase	machinery work cost	watering	total	production (kg)	income (yuan)	pure profits of farmers (yuan)
before trusteeship	450	330	270	1050	800	2080	1030
after trusteeship	420	170	240	830	900	2340	1510
land conversion							500 (rental income)
cost savings and profit increase	30	160	30	220	100	260	

Source: Data from Shanxi Hengxing Agricultural Technology Development Co., Ltd.

3.1.1 Bridging agricultural machinery service & market bottlenecks

Heng Xing has improved the degree of land integration and continuous plotting by organizing agricultural land resources. At the same time, relying on the advantages of cross-regional operation, the company organizes and dispatches agricultural machinery operators in different regions to dock with demand, and to secure the supply for machinery in agricultural-busy season across different regions.

3.1.2 Agricultural production supervision & management platform

In order to better carry out production management, Hengxing has developed a self-use agricultural production management Application "Nonglebao". "Nonglebao" can realize the positioning monitoring of agricultural machinery, automatically collect operation scope, quality, trajectory and other operation information, strengthening the supervision of agricultural machinery operators and ensuring the quality of trusteeship services. Also, the platform can help meet the requirements from authorities for the dynamic management of trusteeship production information.

3.1.3 Green and sustainable agriculture practices

Hengxing Company uses more environmentally friendly fertilizers and pharmaceuticals in its production process, which effectively reduces chemical pollution. In addition, the company recycles the straw and processes it on its own and sells it to the downstream of the industrial chain, which not only become an important profit link of the company, but also prevent farmers from burning straw on the land.

3.2 Multi-subject Linkage Trusteeship Management Model

The promotion of agricultural trusteeship, especially the expansion of its scale, has raised new problems for the agricultural trusteeship model. We noticed, through investigation, that Hengxing mode faces several difficulties as the company expands its business province-wide, including the limited industrial chain, an improvable machinery-operator management platform, dilemma in financial support, etc.

With the aim of safeguarding food security and eradicating poverty, we have designed a multi-subject linkage trusteeship management model (seen as in Figure 4 below) which involves the service organization, the government and the village collective. The mechanism features organization as its underlying logic and it would be conducive to expanding the business scale of agricultural trusteeship and improving its economic benefits. We believe that these subjects in this model should play the following roles.

3.2.1 Service provider: multi-functionalized cores

Service providers can extend agricultural industrial chain. Trusteeship service organizations can integrate grain collection points and help farmers sell their grains to increase their incomes. The existing trusteeship services are mostly limited to agricultural production, while the back-end industry is rarely extended. Farmers are at the end of the information chain and are limited by their level of knowledge and short-term interest concept. It is difficult for them to choose a reasonable selling time in the grain sales season, and their income is easily affected by short-term market fluctuations. We believe it might be conducive to alleviating this problem if trusteeship service organizations integrates farmers as well as grain collection points. This requires farmers to uniformly hand over grain sales to the trusteeship service organization for handling, and the service organization integrates grain collection points for sale.

First of all, due to the large production scale of the trust organization, it can effectively integrate major grain collection points within the production area, so the collection points wouldn't have to collect grains from the farmers separately, thereby reducing the transaction cost in grain acquisition. Secondly, the agricultural trusteeship organization can be helpful in improving the bargaining power of farmers. For example, trusteeship organizations can explore a grain collection guarantee contract mechanism, in which the trusteeship service organizations sign an amount-guarantee contract with the integrated grain collection point so as to avoid collection points driving down prices and ensure the income of farmers. Thirdly, compared with individual farmers, agricultural trusteeship organizations are advantageous in information collection and grain price prediction. They can grasp the best sale time and ensure that farmers' income is less affected by short-term market fluctuations.

Service providers can also develop agricultural machinery service platform. Based on the existing agricultural machinery operator management platform, combined with new generation of information technologies such as big data and artificial intelligence, service providers can design a new generation of functional expansion platform to integrate comprehensive agricultural services and realize

efficient management of people, machines and land. **Firstly, the platform should include an efficient supply-demand linkage mechanism. The agricultural machinery service platform collects and integrates the agricultural service needs of farmers through the platform and release them.** Agricultural machinery operators can directly connect the needs through the platform, which greatly saves the communication cost of the trusteeship organization. This platform is different from the existing national agricultural service docking platform and has two major advantages: first, it integrates service demand into regular-shape farmland, which is conducive to the operation of agricultural machinery operators. The second is to achieve accurate supply. The platform organizes and integrates the information of agricultural machinery in the county, which is more accurate and implementable than the national service docking platform. **Secondly, the platform should also serve as a comprehensive service acceptance mechanism.** In addition to the existing inspection on operation scope, quality and trajectory, it should be able to monitor crop growth and abnormal situations. The operation data should be accessible for both service organizations and farmers, so that farmers can see the production of their farmland on their phones. The digitization and intelligence of agricultural supervision is conducive to improving the authenticity and security of data and improving service satisfaction.

3.2.2 Government: strengthened support

The Shanxi Agricultural Trusteeship Service Regulations of 2021 clarified the government's responsibilities in supporting and regulating agricultural trusteeship. Under the Regulations, Shanxi Province has continuously increased its support for trusteeship services. Based on its existing practice, we put forward the following suggestions.

Government should issue subsidies based on bidding competition. Through preliminary research, the government determines the project points and the subsidy amount in different villages. The mode of service before subsidy is adopted, that is, after the implementation of each link is completed and passed the review and acceptance, the service organization will cash the subsidy funds according to the link. It'll drive market competition and promote the improvement of the service level of service subjects.

Government should promote agricultural finance innovations. According to our research, Trusteeship enterprises often face finance issues at the initial stage of agricultural production. Most of the agricultural trusteeship service organizations in China are still in their infancy, characterized by weak economic strength, and their assets are insufficient for pre-harvest input. Meanwhile, Settlement methods rely mainly on post-stage and final payments—at Hengxing, for example, only about 10% of farmers prepay. This creates early financial pressure that hinders production and limits service expansion. Against this backdrop, enterprises adopting the model of integrating (instead of owning) agricultural machinery as the primary means of acquiring machinery services confront the issue of limited fixed assets and a lack of collateral for mortgages. Therefore, there is a need to explore new credit loan financing mechanisms. Currently, the determination of credit loan limits for new agricultural business entities in China primarily relies on enterprise assets and liquidity. These criteria make it

difficult to objectively assess the loanable amounts for trusteeship service entities with a relatively small number of agricultural machines. In response, we propose two solutions.

(1) Credit loan innovations for trusteeship organizations.

As a new type of credit loan, the "trusteeship loan" for service organizations should develop new criteria for determining the amount of credit. At present, similar forms of "trusteeship loan" for agricultural service providers have been practiced in Changzhi, Shanxi and other cities in China, but they still face problems such as limit restrictions and fixed limit certification standards, which need further innovation. We believe such loans should grant loans based on the number of hectares entrusted to the trusteeship service provider and the farmers, thereby recognizing the providers' service scale more accurately.

(2) Credit loan innovations for farmers

In February 2024, The department of agriculture and rural affairs of Shanxi province issued a notice demanding cities to organize financial institutions to connect with trusteeship service providers to explore and carry out trusteeship loans, trusteeship insurances and other financial products, in a bid to alleviate the difficulties of capital turnover of service providers.

This type of loan takes the contracts signed between farmers and trusteeship service organizations as the entry requirement. It aims to assist farmers in changing their settlement methods by actively opting for advance payments. This, in turn, alleviates the upfront investment pressure on trusteeship service organizations and provides favorable conditions for the expansion of their business. Meanwhile, the "trusteeship household loan" can effectively share credit risks. Furthermore, this loan can be facilitated through the internet, allowing farmers to upload their trusteeship contracts and complete the loan process via mobile Apps, thereby making the loan process more convenient.

3.2.3 Village Collectives: institutionalized intermediaries

Establishing a leading organization is a necessary measure to institutionalize the intermediary function of village collectives. The village of Dongweimao in Hunyuan County, which was investigated by our team, has established a trusteeship team within the village collective. Led by the village secretary and composed of the village chief and committee members in charge of the collective economy from the village committee, this team has effectively enhanced the institutionalization of the matching, management, and supervision of trusteeship services within the village, and is conducive to improving their negotiating position.

Village collectives should play intermediary roles. As previously mentioned, promoting trusteeship services through village collectives can effectively organize farmers. This will significantly reduce transaction costs and ensure scale benefits for the services. For instance, in Dongweimao Village, villagers indicated that most farmers became aware of the advanced nature of this model through promotional activities organized by the village committee, and participated in it under the committee's organization. We believe that the village collective can conveniently and quickly contact and organize

farmers by holding lectures, posting posters, broadcasting We Chat group notifications, etc., to help farmers understand the advantages of trusteeship and organize farmers to sign agreements.

Village collectives can actively leverage its organizational function and lead the trusteeship team to supervise the quality of trusteeship services. Since most farmers are far away from their hometowns, they find it difficult to supervise the quality of trusteeship services and lack effective means of doing so. Therefore, village collective may take the role and enhance the effectiveness of supervision.

3.3 Impact assessment: From short-term to long-term

In the short term, this trusteeship model can bring a variety of benefits to various subjects. In the medium term, this model has strong sustainability and can promote the coordinated development of urban and rural areas. In the long term, this model is conducive to achieving common prosperity, and, If promoted in countries with similar demand, it is sure to help ensure food safety and alleviate poverty, thus contributing to building a community with a shared future for mankind.

4. Feasibility analysis

Promoting China's agricultural trusteeship model globally holds significant importance in contributing a "Chinese solution" to addressing the challenges of smallholder agricultural development and advancing agricultural modernization worldwide, thereby facilitating the agricultural modernization of all nations. Currently, agricultural modernization across the world is broadly categorized into three tiers: developed agricultural countries (e.g., the United States, Canada, Japan, and South Korea), developing agricultural countries (e.g., China, India, Brazil, Mexico, Argentina, and Malaysia), and least-developed agricultural countries (e.g., Papua New Guinea, Lesotho, and Fiji). The development level of agricultural productive services (exemplified by agricultural trusteeship) aligns with these three tiers.

For **Tier 1 countries that have fully achieved agricultural modernization**, their agricultural productive services are mature, with high efficiency in agricultural factor market allocation, advanced agricultural specialization, and a dynamic equilibrium between agricultural productive services and modern agricultural development. These countries have established a collaborative service supply mechanism involving governments, social organizations, and market forces. They are now driving agricultural modernization through cutting-edge technologies and innovative models to upgrade their agricultural productive services.

Most **Tier 2 developing countries** (e.g., led by China, also including India, Brazil, Mexico, Argentina, and Malaysia, etc.) are at a stage of preliminary or partial agricultural modernization. Their agricultural modernization relies on industrialization and agricultural technological progress, supported by government-led public welfare service systems and rapidly growing markets for full-chain agricultural production services.

The economic transition in the EECA (Eastern Europe and Central Asia) countries left these economies with similar agricultural land situations as China. These countries have excessive land

fragmentation and small average farm sizes. Meanwhile urbanization left a large number of abandoned arable land in rural areas, which requires optimized land allocation mechanisms.

However, constrained by underdeveloped agricultural equipment, limited technological capabilities, and imperfect factor markets, their agricultural productive services still lag behind the demands of accelerating modernization. Some countries including Kazakhstan and Tajikistan restrict land sales legally. But land circulation is still happening in forms like long-term lease. These countries might promote our trusteeship model and bring reallocation of farmland back in the legal framework.

Another type of countries in the EECA region develop land market. Some countries improve the land market to promote land transactions. However, one of the biggest obstacles to this model is the high transaction cost. These countries can learn from our organizational ideas. For example, in some countries, due to the decrease in rural population, land transactions are difficult. These countries can promote land integration through cooperatives, which play an organizing role in persuading farmers into participating in the land market. The land bank of Galicia in Spain is a good example. However, the transplantation of this Spanish model depends on a well-organized land registration system and digital infrastructure, which are not available in the EECA countries. Therefore, it is more effective to adopt our plan to make full use of local cooperatives to promote land integration.

Tier 3 countries face even more severe challenges. These nations, primarily in Asia, Africa, and Oceania, possess favorable natural conditions for agriculture (e.g., climate, soil) but suffer from underdeveloped supporting agricultural services. Their agricultural systems remain dominated by traditional, outdated practices, lacking the external conditions for specialization and division of labor necessary to initiate agricultural productive services. While many have established basic public welfare agricultural service systems—focusing on agri-tech extension, farmer education, and agricultural insurance—these systems are small-scale, low-level, and often technologically dependent on foreign aid.

The following analysis will focus on how Tier 2 and Tier 3 countries can adapt and implement our refined agricultural trusteeship model by improving their internal conditions to achieve agricultural service modernization in the future. To ensure feasible adoption of agricultural trusteeship, these countries must meet four prerequisites (or rather, four critical loopholes that need to be addressed, which would serve as "docking grippers" for our refined trusteeship model):

4.1 Having a huge gap between the actual & theoretical production efficiency

In traditional smallholder farming systems, issues such as fragmented landholdings, insufficient capital investment, and outdated technology are major factors constraining agricultural development in developing countries. Moreover, these challenges contribute to agricultural production efficiency falling far short of the levels theoretically attainable through optimal resource allocation.

Take Ethiopia as an example. There exists a significant gap between Ethiopia's actual agricultural production efficiency and its theoretical potential. The study "Productivity and Efficiency Heterogeneity among Maize Smallholder Farmers in Ethiopia" by Mengistu Alemu et al. (2024)

reveals that the average maize productivity in the study area was 3237 kg/hectare, below the global average of 5000 kg/hectare. Land fragmentation, with an average of 3.73 plots per household and an average farm size of 1.08 hectares, negatively impacted technical and allocative efficiencies. Insufficient capital investment led to inefficient input use, resulting in lower productivity. Only 43% of farmers used improved maize seeds, which could have increased productivity by 16.80%. These factors, combined with limited access to advanced technologies, contributed to an average technical efficiency of 85.60%, economic efficiency of 86.10%, and allocative efficiency of 73.80%. Addressing these issues through policy interventions and development initiatives could significantly bridge the gap between actual and potential agricultural production efficiency in Ethiopia (Alemu et al., 2024).

It is precisely due to the significant gap between current production efficiency and its theoretical potential that the agricultural trusteeship model can exert its remarkable enhancement effect. By centralizing the management of fragmented land, consolidating capital investment, and incorporating advanced agricultural technologies, the trusteeship model is expected to substantially improve total factor productivity, thereby narrowing the gap between actual and potential output. This proposition can be demonstrated by employing the Cobb-Douglas production function. The standard form of the Cobb-Douglas production function is

$$Q = A \cdot L^{\alpha} \cdot K^{\beta}$$

Currently, the gap between actual agricultural production efficiency and its theoretical potential is reflected in this function as a low A value. This is due to farmers' lack of advanced technologies (such as precision agriculture and smart machinery) and inefficient resource allocation. Labor (L) is fragmented and lacks sufficient skills, leading to low marginal productivity ($MP_L = \alpha \cdot Q/L$). Capital (K) is redundantly invested, such as the high idle rate of small-scale agricultural machinery, resulting in low utilization efficiency and similarly low marginal productivity ($MP_K = \beta \cdot Q/K$). Additionally, land fragmentation prevents the realization of scaled economies. Therefore, the actual output of smallholder farming is:

$$Q_{actual} = A_{low} \cdot L^{\alpha}_{dispersed} \cdot K^{\beta}_{repetitive}$$

And the theoretical maximum output is:

$$Q_{theoretica} = A_{high} \cdot L^{\alpha}_{intensive} \cdot K^{\beta}_{optimal}$$

It is evident that the gap between the two is significant ($Q_{\text{theoretical}} \geq Q_{\text{actual}}$). Agricultural trusteeship can clearly help bridge the agricultural productivity gap by enhancing technical efficiency (increasing *A*), optimizing labor allocation (improving the marginal productivity of *L*), and intensifying capital investment (boosting the marginal productivity of *K*).

4.2 Having a relatively well-developed agricultural machinery & operator service market

The core of the agricultural trusteeship model lies in farmers entrusting part or all of the agricultural production processes to professional service organizations, which requires these organizations to have sufficient agricultural machinery and skilled operators to efficiently complete tasks such as cultivation, pest control, and harvesting. A well-functioning agricultural service market ensures an adequate supply of equipment and talent, thereby providing the necessary support for high-quality trusteeship services. On the contrary, an underdeveloped market can lead to a decline in service quality and efficiency, which in turn affects farmers' income and their trust in trusteeship. From a doctrinal perspective, agricultural production is not only a technical issue but also a systematic engineering project that coordinates resources from multiple parties. Only by relying on effective resource flow and allocation can the core value of the trusteeship model be realized, thereby ensuring its stable implementation and widespread adoption. Therefore, a sound agricultural machinery and operator service market is the fundamental guarantee for promoting the agricultural trusteeship model.

Take India as an example. According to a report by Mordor Intelligence, India's agricultural machinery market is projected to grow from USD 18.15 billion in 2024 to USD 27.29 billion by 2029, at an annual growth rate of 8.5%. This expansion is primarily driven by rising mechanization, increasing popularity of tractor custom hiring, and robust governmental support. Under the Sub-Mission on Agricultural Mechanization (SMAM) initiated in 2014–15, the Indian government has already established over 27,500 custom hiring centers that provide more than 1.3 million agricultural machines. Moreover, the market for skilled agricultural machinery operators is also exhibiting strong growth, as more farmers opt to rent agricultural equipment, thereby reducing costs and enhancing machinery utilization. These developments offer farmers more convenient and efficient services, further stimulating the prosperity of the agricultural machinery market (INDIA AGRICULTURAL MACHINERY MARKET (2019–2029)). A well-functioning agricultural machinery and operator service market in India is crucial for the success of the agricultural trusteeship model, as it ensures the availability of necessary resources and supports high-quality, efficient trusteeship services.

4.3 Harboring quasi-village collectives

Quasi-village collectives, as critical institutional vehicles for agricultural trusteeship, address the efficiency challenges of fragmented smallholder farming through organizational integration. Their core functions operate on two dimensions: First, by leveraging collective coordination mechanisms to aggregate land, labor, and capital inputs, they achieve scaled economies in agricultural machinery services and bulk procurement of production materials, thereby reducing unit production costs. Second, through organized bargaining power, they reshape power dynamics in agricultural supply chains, compressing intermediary markups in input procurement and forming price-negotiation alliances in product sales to enhance farmer incomes. These collectives also internalize positive externalities by providing public goods such as irrigation infrastructure maintenance, agricultural technology extension, and market information platforms, filling gaps in government public services. Their risk-sharing mechanisms, including mutual insurance and guaranteed-income contracts, mitigate

risks from natural disasters and market fluctuations. Linking farmers with external service providers, quasi-village collectives utilize their deep understanding of local agricultural practices and demands to assist farmers in selecting appropriate service providers, facilitate communication and coordination, support contract management, and promote the adoption of new technologies to improve production efficiency.

Globally, quasi-village collectives exist widely as an inevitable outcome of human societal adaptation to environmental and economic challenges. In agrarian societies, the need to coordinate labor and resources for farming activities have driven the formation of village collectives. These organizations, often rooted in kinship, shared beliefs, and traditional customs, provide frameworks for cooperation and mutual aid. In agricultural settings, unpredictable challenges such as weather and pests necessitate collective efforts to reduce risks and ensure food security. By pooling resources, sharing knowledge, and coordinating efforts, quasi-village collectives effectively address these challenges. Additionally, in agrarian societies marked by inequalities in land ownership, wealth, and power, these collectives emerge as platforms for resolving disparities and empowering marginalized groups, enabling collective bargaining for better product prices and resource access.

A modern example is India's Amul Dairy Cooperative, a quintessential quasi-village collective. Established in 1946 and collectively owned by 3.6 million dairy farmers, Amul organizes decentralized milk producers by providing unified processing and marketing services. Similar to Chinese village collectives, Amul enhances production efficiency through standardized practices, technical guidance (e.g., high-quality feed and veterinary services), and price-guaranteed procurement contracts, safeguarding farmers' interests.

However, despite Amul's success, India's agricultural services remain lagging in modernization, one of the million pieces of evidence attesting the urgent needs to implant our refined agricultural trusteeship model with the help of existing quasi-village collectives.

Still exemplifying through India's Amul Dairy Cooperative. Its impact is largely confined to dairy, while other agricultural sectors (e.g., grains, horticulture) lack comparable institutional frameworks. Most Indian cooperatives are niche-oriented, failing to address cross-sector needs like mechanization, irrigation, or supply chain integration. Moreover, even within cooperatives, India's average farm size remains small, limiting scalability. Finally, Amul's financial model relies on farmer equity and retained earnings, but most smallholders lack access to formal credit for advanced inputs (e.g., smart irrigation systems). National credit systems remain skewed toward large landowners, excluding marginal farmers.

Our agricultural trusteeship model can effectively address these challenges by: first, integrating existing agricultural machinery and operator resources available in the market, while enhancing cross-sector collaboration by extending the industrial chain, and second, systematically consolidating fragmented landholdings and, once refined, providing financial support to smallholders in need through microfinance mechanisms such as small-scale credit programs. This approach aligns

fragmented resources into cohesive systems, bridges institutional gaps, and empowers farmers through tailored financial inclusion strategies.

4.4 Being willing to expand their traditional concepts of food security

Globally, significant variations in natural conditions, climate zones, and resource endowments render the conventional model of food security—centered on three staple crops (rice, wheat, and maize)—inapplicable to many developing countries. In regions where agro-ecological conditions inherently restrict large-scale cultivation of staple crops, traditional agricultural trusteeship models often fail to ensure food security. This necessitates a conceptual shift from narrow "grain security" to a holistic "Grand Food Perspective", which redefines food security as a multidimensional system encompassing grains, meat, vegetables, aquatic products, and even microbial-based foods across entire supply chains.

Under the Grand Food Perspective framework, food security transcends mere carbohydrate supply to prioritize diversified nutritional needs, health outcomes, ecological conservation, and sustainable resource utilization. This paradigm emphasizes ensuring not only caloric adequacy but also high-quality supplies of protein-rich foods, vegetables, and fruits. It calls for integrating land resources—including croplands, grasslands, forests, oceans, and biodiverse ecosystems—into a modern agricultural system that aligns with ecological constraints (see Opinions on Implementing the Grand Food Perspective to Build a Diversified Food Supply System). To operationalize this perspective, agricultural trusteeship models must adapt to local agro-ecological realities. For developing countries constrained by environments unsuitable for staple crops, replicating China's grain-centric trusteeship approaches proves ineffective. Instead, trusteeship services should focus on resource-compatible production systems, such as promoting drought- or salt-tolerant crops in arid or saline regions while integrating advanced irrigation and precision management technologies.

Take Egypt as an example. The Nile Delta in Egypt faces severe constraints in traditional grain cultivation due to soil salinization and water scarcity. However, the integration of high-value salt-tolerant crops with aquaculture presents a viable pathway for composite agriculture, as evidenced by existing precedents. Following the construction of the Aswan High Dam, secondary salinization in the Nile Delta has intensified (Zhang Shuai, Egypt's Food Security: Challenges and Causes), reducing the efficiency of wheat and rice production. To address this challenge, local governments can collaborate with agricultural service organizations to implement adaptive trusteeship strategies under the "Grand Food Perspective." This includes promoting salt-tolerant crops such as barley, quinoa, and Salicornia (sea asparagus) while utilizing trusteeship services to integrate seed selection, drip irrigation technology, and soil remediation. Additionally, saline-alkali water bodies can be converted into tilapia and shrimp farming zones, establishing a three-dimensional production system. To enhance climate adaptability, Israel-inspired smart drip irrigation systems with sensors and remote-control devices can be deployed for precise water-fertilizer management, while cooperatives can consolidate fragmented saline-alkali plots and introduce solar-powered desalination units to expand quinoa cultivation,

perfectly following the ecological sustainability principles of the “Grand Food Perspective.” Furthermore, value chain expansion efforts can involve partnerships with processing enterprises to develop high-value-added products (Salicornia protein powder and quinoa energy bars), connecting farmers to international health food markets to increase income. Finally, financial innovation can support these initiatives through “saline-land agriculture credit” programs, where local banks provide low-interest loans collateralized by projected revenues, helping smallholders overcome capital shortages and ensuring the sustainability of these agricultural practices.

Through these adaptive measures, all similar regions worldwide can transcend the conventional “staple crop-centric trusteeship” model and establish a diversified food production system tailored to local resource endowments. This approach not only addresses food security challenges but also promotes its sustainability by harmonizing productivity with ecological resilience.

5. Conclusion

Shanxi, one of the cradles of Chinese agrarian civilization, developed its agricultural ingenuity through dynamic interactions with the harsh Loess Plateau environment, historical practices, and cross-cultural exchanges. The region’s arid climate, with 70% arid land and concentrated summer rainfall, necessitated innovations in dryland farming.

Historical continuity shaped Shanxi’s agricultural heritage. The legendary Emperor Shennong’s experimentation with millet and foxtail millet at Yangtou Mountain laid the foundation for staple crop cultivation. Institutional innovations, such as the Xia Dynasty’s fallow system and Northern Dynasties’ crop rotation practices, optimized land sustainability. By the Han era, Shanxi had already become a hub for disseminating farming technologies, spreading dryland techniques along the Fen River to pastoral regions.

Shanxi’s agricultural wisdom epitomizes sustainable agroecology under resource constraints. From Shennong’s wooden plows to precision dryland systems, its legacy reflects a philosophy of harmonizing human ingenuity with natural rhythms—a timeless model for ecological resilience.

Now, it is time to propagate Shanxi’s agricultural wisdom to the world.

The dissemination of Chinese agricultural wisdom to developing and less-developed nations not only stems from our ecological philosophy of "harmony between humanity and nature" (tianren heyi), but is also actuated by our concept of "teaching fishing rather than giving fish" (shouren yiyu), which extends the historical tradition of localized knowledge transfer, exemplified by Zhang Qian's agricultural technology diffusion along the Silk Road. Moreover, Confucian ethics of "assisting the world when prosperous" (da ze jianji tianxia) also underpin China's agricultural technical assistance programs.

In conclusion, our revitalized trusteeship model inspired by Shanxi offers a transferable solution combining land consolidation without dispossession, input optimization, and financial inclusion. By adapting its governance structure to Ethiopia’s communal norms and leveraging traditional mutual aid systems (Eder, Ekub), the model could elevate smallholder productivity by 35 – 42%—projected from

Shanxi’s 22% cost reduction and 13% yield increase. Successful transplantation hinges on calibrating the model to Ethiopia’s agroecological diversity and institutionalizing grassroots innovations as anchors for sustainable growth. This approach aligns with Ethiopia’s wheat export achievements in 2023 and underscores the transformative potential of Sino-Ethiopian agricultural collaboration.

In summary, our proposal outlines an innovative agricultural production trusteeship model, grounded in empirical research from Hunyuan County, Shanxi Province, aimed at bolstering food security and poverty alleviation. By optimizing the collaboration among service providers, government entities, and village collectives, the model seeks to overcome the limitations of smallholder farming, such as land fragmentation and high transaction costs, thereby enhancing agricultural productivity and farmer incomes. The proposed framework not only aligns with the United Nations’ Sustainable Development Goals, particularly the eradication of poverty and hunger, but also provides a replicable blueprint for other developing countries (especially the Tier 2 and Tier 3 countries mentioned above) facing analogous agricultural challenges or possessing similar preconditions to implement our agricultural trusteeship model. Through this systematic approach, we aim to make substantial contributions to global food security and sustainable development, promoting a shared future of prosperity. This dissemination paradigm represents the resonance between China's traditional "ethics-guided benefit" (yili xiangji) philosophy and the modern "co-construction and sharing" global governance concept. From 1960s African state farm assistance to contemporary digital agriculture exports, China has reconstructed agricultural technology transfer pathways through intelligent machinery and big data, forming a global agricultural innovation model where ancestral wisdom dialogues with digital civilization. We hope as Shanxi’s agricultural wisdom joins the torrent, the construction of a genuine community with shared future for all will be closer and closer to completion.

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Author Contributions

Yichen He: Writing, Original draft, Conceptualization, Methodology. Xuanchen Zhang: Writing, Original draft, Conceptualization, Background analysis. Jiarui Wang: Original draft, Scheme design. Chenqi Yan: Original draft, International Promotion

Availability of Data and Materials

The data used in this study are confidential at the request of Shanxi Hengxing Agricultural Technology Development Co., Ltd.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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