

A Study on the Impact of Women's Empowerment on Food Security: Based on the Perspective of Agricultural Production Diversity

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ABSTRACT

This study analyzed the role of women's empowerment in diversifying households' diets through their production. Based on the survey data of 1185 rural households of Yunnan, Guizhou, Shaanxi, and Gansu provinces in 2021, this paper measured women's empowerment level from five dimensions: agricultural production, credit resources, income control, leadership, and time allocation. It targeted food safety and further analyzed the role of agricultural production diversity in the pathway of women's empowerment impact on households' food security. The estimation showed that improving women's empowerment enhances diet quality and increases agricultural production diversity. Meanwhile, agricultural production diversity was conducive to improving the food security level of households. After carrying out the mediation effect test, the paper found that agricultural diversity partially mediates the effect of women's empowerment on food security and a total mediation effect on women's empowerment and food security in the poor group. Furthermore, agricultural diversity could further promote households' food and nutrition security based on women's decision-making ability.

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Introduction

Since the reform and opening up, China's food production and supply have grown significantly, with the overall situation characterized by sufficient quantity and energy. In 2022, the country's total food production will reach 680 million tons, and the per capita food supply will be 600 kilograms, with an adequate and varied food supply. In 2022, the country's total food production will reach 680 million tons, and the per capita food supply will be 600 kilograms, with an adequate and varied food supply. However, with the introduction of the strategy of building an "all-encompassing approach to food," which emphasizes the need to ensure the adequate supply of various types of food, such as meat, vegetables, fruits, and aquatic products, while ensuring the supply of food, new requirements have been put forward to improve the structure of food consumption further. On the one hand, there is a need to re-conceptualize and redefine food security in the context of the "all-encompassing approach to food," where food diversity becomes the primary expression of food security [1]. On the other hand, there is a need to seriously consider the new requirements of the "all-encompassing approach to food" for agricultural production and how to meet the evolution of people's food consumption structure from enough to eat to a more excellent range of choices.

As China's urbanization process continues to advance, "men go out to work, and women stay behind to work in agriculture" has

become a rational choice of strategy for families to maximize benefits and avoid risk impacts, which to a certain extent reflects the rationalization of the gender division of labor [2-7]. However, women simultaneously face the dual pressures of agricultural production and food preparation. On the one hand, women are increasingly linked to agricultural inputs, technology adoption, and food security, and their essential role in agricultural production is becoming more prominent; On the other hand, as women are the primary caretakers of household food consumption and nutritional intake, increasing women's empowerment can increase household food consumption expenditures and improve the nutritional status of children and families. A critical factor in achieving sustainable agricultural production and food security in rural areas is promoting women's primary development capacity and empowering their voices in production and life [1,8-13].

In underdeveloped areas of western China, poor ecological environments, underdeveloped markets, lack of capital, and weak infrastructure are significant constraints to their development. The western regions, which are primarily mountainous and lack the advantages of large-scale food cultivation, have created objective conditions for the diversification of agricultural production. However, the low level of dietary diversity is still the main problem plaguing farmers in the region. Thus, this paper takes smallholder farmers in the less developed areas of western China as the object of study and incorporates gender, food and nutrition security, and agricultural production diversity into the same research framework, which is in line with China's national conditions and of practical significance.

There has been a gradual increase in academic research on the relationship between agricultural production and food and nutrition security. However, the issue was seldom explored from a gender perspective. Gender and women's empowerment are rarely included in the research on elements that impact household food security, and even fewer studies have explored in detail the impact of agricultural production diversification on women's empowerment in household food security.

This paper utilizes 2021 farm household research data from seven counties in Yunnan, Guizhou, Shaanxi, and Gansu provinces to explore how women's empowerment and agricultural production diversity affect food security. Compared to previous studies, this paper bridges the gap in this research issue in the country. First, this paper measures the status of women's empowerment in underdeveloped regions by constructing a women's empowerment index, which puts forward new ideas for distinguishing the level of empowerment in different dimensions and provides a new analytical method for research in this area; Second, this paper incorporates women's empowerment, food and nutrition security, and agricultural production diversity into the same research framework and further analyzes the mediating effect of agricultural production diversity in the impact of women's empowerment on food security, expanding the research perspective.

Theoretical Analysis and Research Hypothesis

Impact of Women's Empowerment on Food and Nutrition Security

In most rural households, the responsibility for the nutrition of family members falls on women [1,14]. However, women's general lack of control over household assets, knowledge, and social support networks is a significant barrier to improving malnutrition [15]. Numerous studies have shown that empowering women increases female participation in household decision-making, affecting household well-being and food security [16-17]. On the one hand, improving women's household status (empowerment) impacts their access to and control over resources, increasing the likelihood of allocating more resources to food and contributing to the household's food security. On the other hand, women's empowerment has led to reduced household welfare and a lower level of dietary diversity [18,19]. This is mainly because the more women have a voice in agricultural production, the more time they devote to agricultural production activities and the less time they have to take care of the household and food preparation, which in turn affects their nutritional status and that of their family members [20]. At the same time, the improvement of women's status may break the gender rules inherent in the family, leading to domestic violence against women, thus indirectly affecting the food security situation of the family [21].

The first research hypothesis is proposed based on the existing studies: women's empowerment contributes to household food security (H1).

Impact of Women's Empowerment on the Diversity of Agricultural Production

Agricultural production diversification as an ex-ante management strategy for farmers to avoid risks and cope with shocks is closely related to gender factors [22-24]. On the one hand, women tend to be "passively empowered" in the less productive agricultural sector due to male labor migration. In contrast, women's access to agricultural resources (credit, technology, services, etc.) has remained the same, which, to some extent, adversely affects the diversity of farm production and integrated agricultural production capacity [25]. On

the other hand, studies have shown that the greater the participation of women in decision-making in agricultural production and their control over household income, the more favorable the increase in the number of crops grown (raised).

The second research hypothesis is proposed based on the above studies: women's empowerment is conducive to diversity in agricultural production (H2).

Impact of agricultural production diversity on food and nutrition security

For smallholder farmers, diversification of agricultural production is often an effective strategy to improve diet and nutritional status [26-28]. Specifically, agricultural production diversity impacts food and nutrition security in two ways: The direct consumption path. In poor rural areas, smallholder farmers often face bottlenecks such as poor transportation and closed information, and food consumption relies mainly on home-produced crops, with the more diverse the agricultural production, the higher the level of dietary diversity of the household [29]. The market participation pathway. Existing studies have shown that market participation plays a positive role in the correlation between diversity of agricultural production and diet quality and is another possible pathway to increase household dietary diversity, mainly due to the increase in sales income, which allows smallholders to increase their expenditure on food consumption, which in turn contributes to the household's food security [30-33].

Based on the existing studies, this paper proposes a research hypothesis: increasing diversity in agricultural production improves food and nutrition security (H3).

Taking women's empowerment as the starting point and food and nutrition security as the goal, this paper integrates gender, agricultural production, and food security into the same research framework from the perspective of diversity to analyze the impact of women's empowerment on food security, and then further exploring the mechanism of the role of diversity in agricultural production in the effects of women's empowerment on food security.

Thus, we propose the research hypothesis: agricultural production diversity plays a mediating effect in the impact of women's empowerment on food security (H4).

The research framework is shown in Figure 1:

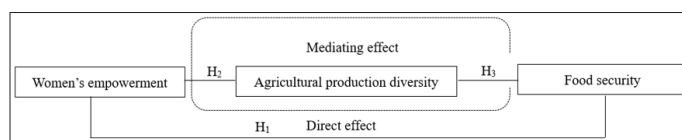


Figure 1: Research Framework Diagram

Research Methodology

Data Sources

The data utilized in this study come from the comprehensive survey of households' livelihoods and food security conducted by the Institute of Agricultural Information of the Chinese Academy of Agricultural Sciences (CAAS) in 2021 in underdeveloped areas of western China, covering seven counties in four provinces: Shaanxi, Yunnan, Guizhou, and Gansu. The terrain in these underdeveloped areas is complex, with 78.9% being mountainous; agricultural production is concentrated on the cultivation of drought-tolerant

crops such as maize, potatoes, beans, and vegetables and the raising of livestock such as pigs, chickens, and ducks; market participation is low, with the average distance from the sample villages to the nearest agricultural market being 37.8 kilometers.

The survey was conducted in July-August 2021 using a combination of multi-stage and random sampling. First, the food security status of the 592 formerly poor counties was analyzed based on food availability, accessibility, and utilization and classified into food security and food insecurity categories using cluster analysis. Second, we selected seven counties from the 271 counties with poor food safety conditions: Zhen'an counties in Shaanxi Province, Qingshui County in Gansu Province, Wuding and Huize counties in Yunnan Province, and Panzhou and Zheng'an counties in Guizhou Province [34]. Third, we used probability proportional sampling (PPS) and random sampling methods to select sample farmers. Specifically, in the first stage, 19 administrative villages were chosen as sample villages in each of the six sample counties, except for Qingshui County in Gansu Province (16 administrative villages); in the second stage, 12 sample farm households were randomly selected from each sample village, totaling 1,560 households.

The survey covered modules on basic information about farm households, property and financial status, agricultural production, income and expenditure, consumption, shocks and coping strategies, and women's empowerment. By eliminating the questionnaires with missing or invalid data in the content module required for this paper, we eventually acquired 1,185 valid sample data. As shown in Table 1, about 37.7% of the respondents were female, with a relatively high proportion in Shaanxi and Guizhou provinces.

Table 1: Sample Description of the Study

Province	County(N)	Village(N)	Household(N)	Female respondents (%)
Shanxi	2	38	331	44.7
Yunnan	2	38	376	33.0
Guizhou	2	38	321	38.3
Gansu	1	16	155	33.5
Total	7	130	1185	37.7

Empirical Specification

To study the correlation between women's empowerment, agricultural production diversification, and food security, this article adopts a stepwise regression approach

$$Food_{sec} = \beta_0 + \beta_1 WEAI_{poor} + \beta_2 I + \beta_3 H + \beta_4 F + \varepsilon \quad (1)$$

$$Diversity_{pro} = \alpha_0 + \alpha_1 WEAI_{poor} + \alpha_2 I + \alpha_3 H + \alpha_4 F + \delta \quad (2)$$

$$Food_{sec} = \lambda_0 + \lambda_1 Diversity_{pro} + \lambda_2 WEAI_{poor} + \lambda_3 I + \lambda_4 H + \lambda_5 F + \vartheta \quad (3)$$

Where $Food_{sec}$ denotes the level of food security; $Diversity_{pro}$ denotes the level of agricultural production diversity; $WEAI_{poor}$ denotes the women's empowerment score; I indicates the women's individual-level characterization variable; H indicates the household-level characterization variable; F indicates the farmland-level characterization variable; β , α , and λ are the estimation parameters in the three models, respectively, and ε , δ , and ϑ denote the random error terms.

Drawing on the study of Wen et al. the model test was carried out in three steps in this paper [35]. Especially, firstly, to test whether the total effect of women's empowerment on food security is significant (β); secondly, to test whether the effect of women's empowerment on agricultural production diversity is significant (α); lastly, to test whether the effect of agricultural production diversity on food security is significant (λ) after controlling for the key variable of women's empowerment. If all of these parameters are significant, it means that agricultural production diversity plays a mediating effect in the impact of women's empowerment on food security. If parameter α or λ is not significant, the Bootstrap method is used for further testing. If α , λ (indirect effect) is significant, the parameter λ needs to be tested for significance. Therefore, if the parameter λ is significant, it proves that there is a partial mediating effect. Otherwise, it is a fully mediated effect.

Construction of Key Variables

Food security. The explanatory variable is household food security, and we used two main methods to measure the level of food security and conduct related robustness tests. One is the Food Consumption Score (FCS), where the consumed food was categorized into eight major food groups (staple grains and stems, meat, dairy, vegetables, fruits, legumes, fats, and oils) based on the past seven days recalling, and the frequency of consumption of each food group was calculated [36]. In the specific calculations, different weights were assigned to each food group. Finally, each food group's consumption frequency was summed with its weight to measure the level of food security. Another is the Household Dietary Diversity Score (HDDS), which is based on a farmer's review of food consumption over the past 24 hours, categorizing the food consumed into 12 major food groups (cereals, stems and tubers, vegetables, fruits, meats, eggs, fish and aquatic products, dairy, legumes, fats, oils and fats, sugars, and condiments). In the specific calculation process, the same weight was given according to the food consumption, i.e., one point was assigned for consumption, and no points were given for repeated consumption [37-38].

Agricultural production diversity. Agricultural production diversity score is one of the key explanatory variables. The level was mainly measured using the household food Group Production Diversity Score (FGPD), i.e., categorizing into eight food groups: cereals, legumes, vegetables, fruits, meat, fish, eggs, and dairy by the crops planted and livestock reared by each household, and for every increase of one category, the agricultural production diversity score was increased by 1 point accordingly [39-40].

Women's Empowerment. Another central explanatory variable is the women's empowerment score. Currently, the meaning and measuring of "women's empowerment" has been defined in various ways in the literature, while the Women's Agricultural Empowerment Index (WEAI) is one of the most widely used and comprehensive indicators among the methods of measuring women's empowerment levels. Specifically, it consists of an empowerment index of five dimensions (5DE)-production, resources, income, leadership, and time a gender equality index (GPI), in which the 5DE weights 0.9 and the GPI weights 0.1 [41-46].

Considering the difficulty of data collection, we constructed an adjusted women's empowerment index, mainly drawing on Abreha's research methodology, and GPI was omitted [47]. Specifically, when a woman participates in decision-making or has access to a specific resource, the value is assigned as one, i.e., the woman is empowered, and vice versa. It is important to note

that when women work more than 10.5 hours, they are considered not empowered in the dimension of time allocation.

The domains, definitions, values, and weights of the women's empowerment scores are detailed in Table 2.

Table 2: Constructing the Women's Agricultural Empowerment Index (WEAI)

Domain	Definition	Value	weight
Agricultural production	If the woman participates in agricultural activity individually and jointly	1=Yes; 0=No	1/5
Credit resources	If the woman participates in decision-making concerning credit individually or jointly	1=Yes; 0=No	1/5
Income Disposal	If the woman participates in decisions regarding the use of income		1/5
Leadership	If the woman is a member of at least one economic or social group		1/5
Time Allocation	If the woman works more than 10.5 hours a day		1/5

Based on the extant literature, it is likely that several other factors affect diet diversity. Consequently, we also controlled, for example, characteristics of individuals, including the women's age, education, health status, income level, and training, etc., additional features of households, including household size, dependency ratio, market distance, migrant workers, and debt etc. Furthermore, we also included other factors at the farmland level, such as the area of arable land, irrigation conditions, etc. All the variables are shown in Table 3.

Table 3: Variables and Values

Variables	Values and meanings
FCS	Food consumption of households in the past 7 days: 0~112
HHDS	Food consumption of households in the past 24 hours: 0~12
FGPD	Agricultural production diversity score: 0~8
WEAI	Women's empowerment scores in the five domains of production, resources, income, leadership, and time: 0~1
Age	Woman's age: years
Education	Women's education level: years
Health	Has the woman been in poor health for more than three months in the past 12 months: 1=Yes; 0=No
Income	Women's wage-earning in the past 12 months: yuan
Training	Have women participated in professional training in the past 12 months: 1=Yes; 0=No
Household size	Number of persons in households: persons
Dependency ratio	The ratio of non-working populations to the working population in the household: %
Market distance	The distance of the household to the nearest market: kilometers
Migrant workers	Was there a migrant worker in your household in the past 12 months: 1=Yes; 0=No

Debt	Was there any debt in the household: 1=Yes; 0=No
Land	Area of arable land: mu
Irrigation	Availability of cropland for irrigation: 1=Yes; 0=No

Descriptive Statistics

As shown in Table 4, the average age of women in the sample area was 52, with 13.1% aged 65 and over. Women's educational level was significantly lower, with less than 5% of women in high school and above and a high illiteracy rate of 39.2%. In the past 12 months, 37.6% of the women had a condition of poor health that lasted more than three months, and among them, 37.6% suffered from chronic diseases; Fewer women participated in training, less than 1/5; more than 1/4 of the women had a wage income, indicating that the women in this region had experience in non-agricultural labor or working outside the home. The average family size is 5.1 persons, and the average total dependency ratio is higher than 50%, which indicates that the region is not in a demographic window of opportunity. The labor burden is heavier, and 51.6% of households have migrant workers. The degree of marketization in the sample area was generally low, with an average distance of 6.6 kilometers from the nearest market. The arable land was characterized by small size, dispersal, poor irrigation, and a monoculture structure, with 85.6% of the farmers depending on the weather and growing an average number of only 2.8 crops.

Table 4: Descriptive Statistics of Variables

Variables	Mean	Std. Dev.	Min	Max
FCS	62.049	25.321	0	112
HHDS	7.014	1.809	0	12
FGPD	2.846	1.173	0	7
WEAI	0.632	0.195	0.2	1
Age	52.941	10.094	25	81
Education	3.885	3.840	0	16
Health	0.376	0.485	0	1
Income	0.178	0.383	0	1
Training	2.365	4.023	0	11.51
Household size	5.097	1.694	1	15
Dependency ratio	0.542	0.598	0	6
Market distance	6.561	6.624	0	60
Migrant workers	0.516	0.500	0	1
Debt	0.495	0.500	0	1
Land	26.988	20.588	0	180
Irrigation	0.141	0.348	0	0

By decomposing the women's disempowerment score into five domains, we find that the lack of access to and control of credit resources was the main reason for women's disempowerment. The contribution rate of this indicator to the women's disempowerment score (31.0%) was much higher than its weight (20%), which indicates that women's disempowerment was more prominent than that of other areas, and control of credit resources was severely constrained (as shown in Table 2). Women's decision-making power in agricultural production and income dispositions did not vary significantly in how much they affected women's empowerment and contributed substantially to women's disempowerment. However, the time allocation dimension had a limited effect on

improving women's empowerment levels, contributing only 14.8% to women's disempowerment scores.

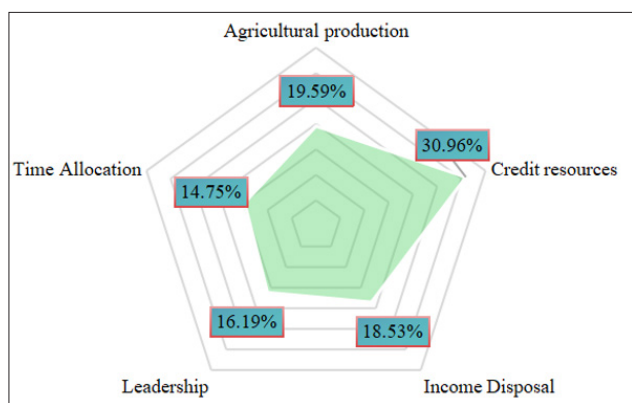


Figure 2: Decomposition of Women's Disempowerment Scores

Research Results and Analysis

The results of the stepwise test models are presented in Table 4. Model I is the baseline regression model for women's empowerment, agricultural production diversity, and food security, with food security measured by dietary diversity score (HDDS). Furthermore, in Model II, the food security level was measured by the Food Consumption Score (FCS)-which was set to test the correlation between the variables and the robustness of the model.

Baseline Model Regression Results

As shown in column (1), the women's empowerment score has a significant effect on household dietary diversity, and the regression coefficient was positive (0.557), which indicated that the increase in women's empowerment level improves the household's diet quality, which was consistent with the findings of Sraboni [1]. At the same time, this validated the research hypothesis I (H1) of this paper that increasing women's empowerment contributes to household food security.

From the results in column (2), women's empowerment score was positive (0.303) at a 5% level of significance, which indicated that empowering women helps to increase the level of agricultural production diversity, and this finding supported the research hypothesis II (H2) in this paper. The main reasons are as follows: on the one hand, for subsistence smallholder farmers, when women have the decision-making ability in the household, they tend to prioritize the family's food consumption and nutritional issues, thus choosing to diversify their agricultural production [48]. On the other hand, when rural women have time agency, they generally run home gardens to produce certain vegetables and fruits for family consumption, thus enriching the level of diversification [49].

The findings in column (3) showed that controlling for FGPD, the women's empowerment score has a significant positive effect on the household dietary diversity score, which suggested that for every one-point increase in the women's empowerment score, the household dietary diversity score improved by 0.481 points when the other explanatory variables were held constant, a finding that once again aligns with the research hypothesis I. Moreover, the coefficient of agricultural production diversity was positive at the 1% level of significance, which indicated that when other explanatory variables were held constant, a 1-unit increase in

the level of agricultural production diversity corresponds to the rise in the household dietary diversity score by 0.249 points, i.e., agricultural production diversity was positively correlated with dietary diversity. The research hypothesis III (H3) was verified. The results of this study were in line with the findings of Sekabira, mainly because in rural areas, the primary source of food consumption for smallholder households was the crops they produce [50].

In summary, the coefficients of β_1 , α_1 , and λ_1 were significant. Thus the research hypothesis IV (H4) was valid, i.e., agricultural production diversity mediated the impact of women's empowerment on dietary diversity. In addition, as mentioned above, after controlling for the effects of agricultural production diversity, the coefficient of women's empowerment (λ_2) was still significantly positive, which suggested that agricultural production diversity played a partial mediating result, and there was a possibility that other mediating effects existed. The total effect (β_1) was 0.557, the direct effect (λ_2) was 0.481, and the indirect effect ($\alpha_1 * \lambda_1$) was 0.075. Thus, the indirect effect accounted for 0.135 of the total effect, i.e., 13.5% of the positive impact effect of women's empowerment on food security was realized through the mediating variable of agricultural production diversity.

In addition, comparing columns (1) and (3) in the model I showed that the effects of the control variables on dietary diversity were consistent and not affected by agricultural production diversity. Regarding the other influencing variables, women's education level, women's training, women's income, household size, and irrigation conditions positively contributed to household food security, and market distance had a significant adverse effect on household food security. Specifically, the more educated women were as the leading managers of household food, the easier it was to acquire knowledge about diet and nutrition, which was conducive to improving the household's diet quality. Training was the primary way for women to develop social capital, which improved the possibility of allocating more resources to food and thus guaranteed the household's food security [18]. The increase in women's income level provided the opportunity to increase the household's food consumption expenditures, which provided a material basis for purchasing food with higher nutritional value. The larger the household size, the more laborers there are, and the broader ways of increasing income are thus conducive to food security. In the less developed regions of China, drought is one of the natural disasters that affects agricultural production, with irrigation conditions ensuring the household's agricultural production and food security. The greater distance from the market created an inconvenience in purchasing food or selling crops, which could have been more conducive to food security.

Meanwhile, the findings in column (2) showed that households with migrant workers did not have a high level of agricultural production diversification, mainly because transferring the family's young and middle-aged labor force out of the country could lead to poor agricultural production and management. The larger the cultivated land area, the greater the possibilities for increasing agricultural production diversification. It was worth noting that the higher the women's education level, the easier it was to accept the new technology in agriculture, which promoted the specialization of agricultural production specialization, and gradually reduced production diversification of the smallholder farmers [51].

Table 5: Stepwise Test Model Regression Results

	Model 1: HDDS			Model 2: FCS	
	(1)	(2)	(3)	(1)	(3)
WEAI _{poor}	0.557**(2.08)	0.303**(2.20)	0.481*(1.81)	15.132***(4.12)	13.991**(3.85)
FGPD	---	---	0.249*** (5.02)	---	3.768*** (5.55)
Age	0.006 (1.01)	-0.001(-0.42)	0.007(1.13)	-0.025 (-0.31)	-0.015(-0.19)
Education	0.028* (1.91)	-0.010*(-1.14)	0.030**(2.05)	0.263 (1.31)	0.291(1.46)
Health	-0.021 (-0.18)	0.008(0.12)	-0.018(-0.16)	-1.775 (-1.13)	-1.735(-1.120)
Training	0.388*** (2.78)	0.117(1.44)	0.357**(2.59)	4.714** (2.47)	4.254**(2.25)
Income	0.031** (2.27)	---	0.036*** (2.67)	0.310* (1.68)	0.389**(2.13)
Household size	0.092*** (2.84)	0.045**(2.35)	0.081**(2.52)	1.373*** (3.08)	1.208*** (2.74)
Dependency ratio	-0.121 (-1.31)	-0.005(-0.09)	-0.118(-1.29)	-1.991 (-1.57)	-1.948(-1.56)
Market distance	-0.029***(-3.75)	0.000(-0.15)	-0.029**(-3.74)	-0.590*** (-5.50)	-0.585**(-5.52)
Debt	0.125 (1.17)	0.074(1.20)	0.108(1.02)	4.049*** (2.77)	3.793*** (2.63)
Migrant workers	-0.118 (-1.10)	-0.148***(-2.33)	-0.083(-0.78)	-0.000** (-2.23)	-0.000(-1.60)
Land	0.004 (0.63)	0.015*** (3.91)	0.001(0.10)	0.050 (0.56)	-0.002(-0.02)
Irrigation	0.471*** (3.13)	0.473*** (5.37)	0.352** (3.06)	7.087*** (3.78)	6.001*** (2.90)
Constant	5.711*** (13.42)	1.915*** (7.92)	5.195*** (11.98)	47.814*** (8.20)	40.023** (6.75)

Note: Columns (1), (2), and (3) in the table correspond to model equations (1) to (3), i.e., the explanatory variables in columns (1) and (3) are food security, and the explanatory variables in column (2) is FGPD; the measure of food safety in model 1 is HDDS, and that in model 2 is FCS; the results have not been duplicated in the table, since equation (2) set in model 2 is the same as that of model 1; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Robustness Tests

As shown in Table 4, this paper conducted a robustness test of the model using the method of replacing the explanatory variables, i.e., replacing the Dietary Diversity Score with the Food Consumption Score (FCS). From column (1) in Model 2, it can be seen that the women's empowerment score had a positive contributing effect on the food consumption score (15.132), i.e., increasing the women's empowerment level contributed to the improvement of the household's food security (H1). From column (3), controlling for this variable of FGPD, women's empowerment scores were significantly and positively correlated with household food consumption scores, which suggested that when all other variables were held constant, for every 1-point increase in women's empowerment scores, household food consumption scores increase by 13.991 points, which was in line with hypothesis I. Further, the coefficient of agricultural production diversity was positive at the 1% level of significance, which suggested that agricultural production diversity had a significant positive effect on household food consumption scores when controlling for the variable of women's empowerment (H3).

Thus, the regression results of Model II were consistent with the baseline regression model (Model I), which suggested that the model regression results are robust, i.e., women's empowerment had a positive impact effect on household food security, and the agricultural production diversity plays a partially mediating role in the impact of women's empowerment on household food security.

Heterogeneity Analysis

To further compare the differences in the impact of women's empowerment and agricultural production diversity on the food security of households with different levels of wealth, this paper classified the sample households into three categories: poor, medium, and wealthy groups by constructing a wealth index (WI) as a proxy measure of the poverty or affluence level of the households and then regressed the baseline model by grouping them once again (Table 7).

Table 6: Impact of Women's Empowerment, Agricultural Production Diversification on Food Security of Households with Different Levels of Affluence

	Poor			Medium			Wealthy		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
WEAI _{poor}	0.826* (1.73)	0.617** (2.17)	0.667 (1.40)	-0.172 (-0.37)	-0.030 (-0.11)	-0.165 (-0.36)	1.069** (2.25)	0.309 (1.17)	0.978** (2.08)
FGPD	---	---	0.258*** (3.03)	---	---	0.223** (2.59)	---	---	0.295*** (3.25)
Constant	6.351*** (8.08)	2.312*** (4.94)	5.755*** (7.17)	5.576*** (7.61)	2.478*** (5.76)	5.021*** (6.62)	5.942*** (7.57)	1.982*** (4.54)	5.356*** (6.73)
N	395			395			395		

Note: Columns (1), (2), and (3) in the table correspond to model equations (1) to (3), i.e., the explanatory variables in columns (1) and (3) are food security, and the explanatory variables in column (2) is FGPD; the measure of food safety in Table 6 is HDDS; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

First, combining the estimation results in column (3) in the poverty, medium, and wealthy groups, it can be seen that controlling for the variable of women's empowerment scores, the coefficient of agricultural production diversity was significantly positive at the 1% or 5% significance level, i.e., agricultural production diversity had a positive effect on food security. In other words, for less developed regions where agricultural production activities are predominant, increasing the agricultural production diversity level improves household food security, regardless of household wealth. Meanwhile, as shown in column (1) for the poverty and wealthy groups, the women's empowerment score had a significant positive impact on the dietary diversity score (food security), i.e., improving women's empowerment contributes to improving the household's diet quality. In addition, to test whether there are differences in the coefficients between groups after group regression, this paper used a test based on the likelihood of no correlation model. The results showed that the coefficient of agricultural production diversity corresponds to p-values of 0.783, 0.769, and 0.574 between poor and medium groups, between poor and wealthy groups, and between the medium and rich groups, respectively; the difference in this coefficient was insignificant. Similarly, the difference in women's empowerment coefficient between the poor and rich groups was insignificant (0.644). This showed that the impact of agricultural production diversity and women empowerment on food security couldn't be determined by comparing the magnitude of the coefficients alone across groups.

Second, based on column (2) within the poverty group, the coefficient of women's empowerment was positive at the 5% level of significance (0.617), which suggested that women's decision-making power is conducive to the diversification of household agricultural production. While controlling for the variable of agricultural production diversity, the effect of women's empowerment score on household food security was no longer significant (column (3)), which suggested that diversification of agricultural production plays a fully mediating effect in the effect of women's empowerment on food security in the poverty group. This is because the poor group in rural areas tends to have a single source of income, and their livelihoods are directly dependent on agricultural production [34]. Therefore, the effect of agricultural production diversification was more pronounced for this group in terms of increasing income and improving diet.

Third, the estimation results in columns (1) and (2) within the medium group showed that the effect of women's empowerment on food security and diversification of agricultural production diversity was not significant, which suggested that in the medium group, the impact of empowering women on improving household agricultural production and food consumption was not significant.

Lastly, column (2) results within the affluent group showed that women's empowerment was not significantly related to agricultural production diversity, i.e., increasing women's empowerment scores does not correspondingly promote agricultural production diversity. In addition, a bootstrap test revealed no mediating effect of agricultural production diversity on the impact of women's empowerment on food security in the affluent group.

Conclusion and Discussion

Based on 1,185 farm household data from seven counties in Yunnan, Guizhou, Shaanxi, and Gansu provinces in 2021, this paper measures the level of women's empowerment in five dimensions, namely, agricultural production, credit resources, income disposal, interpersonal communication and time allocation, and aims at food and nutritional security, to analyze the impacts of women's empowerment on food security, and to further explore the role of the diversity of agricultural production in the effects of women's empowerment on food security.

The study found that

- Improved women's empowerment contributes to higher levels of household food security,
- Women's empowerment has a significant positive effect on agricultural production diversification,
- Agricultural production diversification improves food and nutritional security, and
- Agricultural production diversification partially mediates the effect of women's empowerment on food security.

In addition, women's empowerment has a significant positive impact effect on agricultural production diversity in the migrant farm household group; In the poor group, agricultural production diversification fully mediates the impact of women's empowerment on food security; agricultural production diversification increases household food security regardless of the farmer's distance from markets.

The analysis and discussion of the empirical results highlight the following points: First, women are the largest agricultural producers and have an essential and irreplaceable role in household food consumption. A critical factor in achieving sustainable, productive agricultural development and food security in rural areas is, therefore, the promotion of women's primary development capacity and the empowerment of their voices in the areas of production and life, in particular by enhancing their access to and control over credit resources; Secondly, the empowerment of women emphasizes a "bottom-up" approach, i.e., from raising women's self-awareness to their initiative, rather than the traditional "top-down" approach to empowerment [52]. Third, in the less developed regions, lower diversity in food consumption (diet) remains a significant problem for smallholder farmers and an important aspect affecting smallholder welfare improvement. Thus, based on women's decision-making power, households' food and nutritional security can be further promoted through the diversification of agricultural production.

There are some limitations in this paper: first, the WEAI, which was referenced in this study, is widely used in the research community, but the indicators constructed in different countries and regions need to have uniformity and are all subjectively adjusted. Secondly, since the sample chosen for this paper is a less developed region, whether the findings are generalizable to other areas needs to be further explored. In addition, based on the results of this paper, it is clear that nutrition and health for women and children is also an exciting area of research, but the need for more data on women's and children's diets and nutrition prevented this study from going deeper.

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