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Impact of Rural Women Labour Participation in Agricultural Production on Household Food and Nutrition Security in Punjab, Pakistan

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Abstract

Rural women in Pakistan are involved in diverse household-related reproductive and agricultural-related productive activities. The extant literature fails to capture women's unpaid domestic and farm work. Therefore, this study aims to evaluate the determinants of poor rural women's time allocation to pulses production and the net impact of women's time allocation to pulses production on household food and nutrition security in Pakistan. The findings of the descriptive analysis show that most of the women active in agricultural tasks were middle-aged, illiterate, and had a healthy body (average body mass index) which enables them to perform physically demanding agricultural activities. To correct the endogeneity of women's time for agricultural tasks, we found two unique instruments: women's body mass index and household types of farming. A higher BMI is associated with reduced participation in agricultural activities, possibly due to physical health limitations or reduced mobility. Body mass index decreases women's participation in agricultural activities, while household subsistence farming increases women's involvement in agricultural activities. The results of instrumental variable regression indicate that an hour increase in women's allocation of time to pulse production activities increases food consumption by 102 kcal per adult equivalent per day and household dietary diversity by 6%. Moreover, the analysis reveals that the net impact of reproductive time such as childcare, food preparation, and other household responsibilities on household food security is significantly greater than the impact of productive (agricultural) time. This highlights the crucial role of unpaid care work in ensuring household well-being. Moreover, the net impact of reproductive time on household food security was much more significant than that of productive time. This study suggests that policymakers should compensate for women's increased agricultural workload by integrating health and nutrition interventions into rural development programs thus linking the feminization of agriculture with broader social support systems.

Keywords: Women empowerment, time allocation, food and nutritional security, pulses, Punjab
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1. INTRODUCTION

To ensure food security, a developing country like Pakistan faces many challenges across the production and consumption processes. Food security is the physical, social, and economic access to adequate, hygienic, and nutritious food to meet the basic dietary requirements for every individual's active and healthy life (F.A.O., 2018). Food is a vital requirement that must be met for a good and prosperous existence for all people. This is because malnutrition directly affects health (Ogunniyi, 2021). Among the challenges to food security, the first significant one is the prevalence of poverty which restricts households' access to essential diets. According to the Food and Agriculture Organization (FAO), over 969 million people are impoverished as they are living on 1 USD per day. Out of them, about 795 million poor people face hunger daily (G.N.R., 2016).

Besides poverty, the second significant challenge to food security is poor agricultural productivity which has been aggravated due to the first challenge. Three-quarters of poor people in the developing world are dependent on agriculture. However, they need more resources to invest in modern agricultural technologies to boost crop production (F.A.O., 2018). For a developing country like Pakistan, food security is a topic of primary importance. With 240 million inhabitants, Pakistan is the fifth most populous nation in the world. Around 54% of the rural population in Pakistan suffers from multidimensional poverty and malnutrition (Azeem et al., 2016). This widespread poverty restricts household access to essential diets and is therefore a major challenge to ensuring food security. According to Pandey et al. (2016), the agriculture

sector alone will not be able to meet food security requirements unless a multisectoral approach is adopted to address poverty and malnutrition, simultaneously.

The majority of underdeveloped countries focus on agriculture as an essential sector of the economy and a robust factor for economic growth. Therefore, Pakistan is not an exception as it relies primarily on agriculture to generate national income and employment. The highest proportion of population is actively engaged in agriculture, either directly or indirectly. In several domains of agriculture, women outweigh men in terms of their productive involvement in crop production and animal rearing, but their contributions go unrecognized at national level. This situation is further compounded by ignorance on the part of policymakers who have yet to play their roles to consider and encourage the inclusion of women in agriculture by any gender-divided movements, resulting in the country being deprived of full benefits from women's productive skills and efforts.

Women's employment is also essential for increasing household income and well-being (Aziz et al., 2021). Women's participation in agricultural activities is more important to improving household welfare than men's, but men dominate household decision-making in Pakistan. Women are a prominent segment of any community, but they are poorer and more vulnerable to food insecurity (Jabeen et al., 2013). The role of women in achieving household food and nutrition security is critical. Women contribute 60% to 80% of the total labor force to producing, procuring, and preparing food for household consumption. Despite their significant contribution to the agricultural labor force, 63 percent of rural women are still disempowered in production decision-making (Ahmad & Khan, 2016).Through providing access to physical and financial resources, improving women's participation, and imparting decision-making authority, women could be made to achieve many development objectives, such as poverty reduction, food and nutrition security, good health as well as the well-being of family, etc.

Women’s role in agricultural value addition is particularly significant in agriculture-based countries like Pakistan. They contribute approximately 39% of the agricultural labor force (Ahmed & Khan, 2016), engaging not only in crop production but also in critical post-harvest processes such as seed cleaning, drying, and storage. Despite their substantial involvement, women's contributions are often under-recognized in official statistics and policy planning. Highlighting and integrating women’s roles in value-added agricultural activities is thus essential for improving productivity and achieving food and nutrition security.

Pulses relatively demand low inputs, including water, fertilizer, and pesticides, and their natural nitrogen-fixing characteristics help improve soil fertility and reduce the need to purchase chemical fertilizers. Therefore, pulses leave fewer carbon footprints. Pulses are essential in Pakistan's agri-food systems. They are recognized as the meat of poor people due to their high content of protein (20-40%) and other essential nutrients (amino acids, vitamins, minerals, and complex carbohydrates) and their low price (F.A.O., 2016). Despite the significance of pulses in Pakistan's production and consumption, local production has reduced over the decades. Therefore, to meet growing demand, about 80% of lentils and 10% of chickpeas were imported at an average annual cost of around USD 360 million between 2011 and 2013.

Pakistan is the second-largest importer of pulses in Asia. Enhancing pulse productivity is essential for food and nutrition security in Pakistan. Both men and women are involved in pulse production and harvesting in Pakistan, but women spend more time on seed cleaning, sowing, weeding, harvesting, and value addition. Men are more engaged in outdoor pulse production and marketing activities, particularly water management, input provisioning, transportation, and marketing (Samee et al., 2015). Improved pulse productivity would give poor women more working days for harvesting, drying, and decoding, and better and more timely payments which could enhance their household welfare. However, cultural norms, male dominance, and traditional beliefs are critical constraints to women's labor force participation in rural areas

(Butt et al., 2010). To produce 27% of global pulse production and supply 33% of dietary protein, legumes consume 12-15% of arable land worldwide. On average, Pakistan's pulse output is 0.7 million tons with some fluctuation, while the overall pulse consumption is around 1.5 million tons. Therefore, Pakistan has to import 0.8 million tons of pulses every year. Pakistan imports chickpeas, lentils, and mung beans mainly from Canada, the U.S.A., Australia, China, Russia, Ukraine, and Africa to fulfill the population's demand. The primary reasons behind the low production of pulses in Pakistan are a lack of crop improvement and seed delivery system, abiotic stresses (dryness, heat stress, salinity, and chilling stress), biotic stresses (weeds, fungus, and insect pests), and soil-related problems such as cultivation on poor soils with high ph, low organic matter, low moisture, and increased erosion (Mei et al., 2020). In addition, lack of farm machinery (for sowing, irrigation, plant safety, and application of fertilizers), post-harvest losses, and marketing (no-support price) constraints are bottlenecks in the production of pulses. In Pakistan, pulse production is concentrated in two regions: (i) the Thal desert (spanning the Jhang, Bahawalpur, Khushab, Mianwali, and Layyah districts) and (ii) the Barani region (including the districts of Chakwal, Jhelum, Rawalpindi, and Narowal). In each of the above areas, crop's success depends on the occurrence of precipitation. Over the last five decades, there has been a declining trend in the area and production of chickpeas, lentils, mung beans, and mashed beans.

Few studies have investigated the socioeconomic factors of women's employment and empowerment in Pakistan's agriculture (Naz et al., 2020). However, according to our knowledge, studies have yet to investigate the impact of women's participation in agricultural value chains on household food and nutrition security. In light of this background, this study investigates the role of rural women in pulse production and its impacts on household food and nutrition security. This study adopts a recently developed time-use survey tool by the United Nations to collect data from female heads of pulse-growing households growing pulses in the rainfed region of the Chakwal district of Punjab. Pulses are cash crops for women and smallholder farmers in the poor rainfed region. The study's focus on pulse production and women, mainly responsible for achieving household food and nutrition security, is justified.

The findings of our paper would enhance the understanding of the dynamics of women's participation in pulse production. Moreover, this study would help identify possible interventions for improving women's participation in pulse production as there are few earning opportunities for them in the rainfed region of Pakistan. In addition, this paper contributes to evaluating the role of women in pulse production on household food and nutrition security. Lastly, this study contributes to gender-balanced rural development by improving women's capacity in pulse production.

2. METHOD

2.1. Data Collection

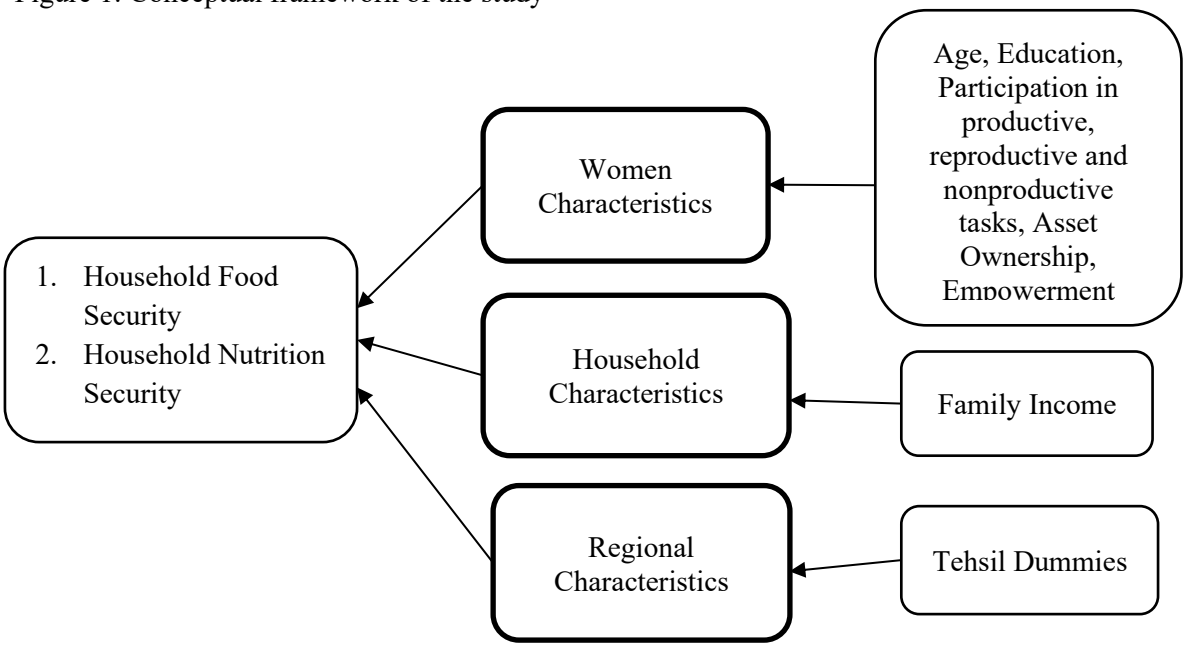
This study conducted face-to-face interviews with female heads of pulse-growing households. A random sampling technique was used to select pulse households from the Chakwal district. Out of the five tehsils of Chakwal district, only three major pulse-growing tehsils, including Lawa, Talagang, and Chakwal tehsils were chosen. Then, a list of pulse-growing households was prepared. From this list, 30 pulse-growing households were randomly chosen, and in the last stage, one female involved in the pulse value chain was interviewed from each household. Hence, a final sample consists of 120 rural women. This study used a pretested and structured questionnaire comprising three sections: household socioeconomic information, women's participation in pulse production using a recently developed time-use survey tool by the United Nations, and a seven-day recall food consumption approach. This survey tool helped us get information about how much time has been allocated by female members of the household at

different levels of pulse production. Hence, this study has unveiled women's contribution to pulse production using an innovative tool. Then, it evaluated the net impacts of women's participation in household food and nutrition security in Pakistan. Interviews were conducted with a team of six female enumerators and a supervisor. Data collection was sponsored by the Australian Center for International Agricultural Research (ACIAR).

2.2. Conceptual Framework

This study is built on household production function theory and the conceptual framework of this study is as follows:

Figure 1: Conceptual framework of the study



2.3. Construction of Variables

2.3.1. Dependent Variables

a) Food Security Status (FSS)

Food security is broadly defined as a condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO). However, due to methodological constraints and the nature of the data collected, this study adopts a more focused measurement of food security which is daily caloric intake per adult equivalent.While this unidimensional indicator does not fully capture the multidimensional aspects of food security (such as psychological stress, food preferences, and long-term stability), it remains a widely used and quantifiable proxy, particularly in agricultural and economic analyses.

The use of caloric intake as a proxy measure is also influenced by feasibility as more comprehensive tools such as the Food Insecurity Experience Scale (FIES) or Household Food Insecurity Access Scale (HFIAS) were not employed in the survey design. Nonetheless, this study recognizes key limitations of using caloric intake alone: (i) possible underreporting due to recall bias; (ii) seasonal variability in food consumption patterns, especially in rainfed areas like Chakwal; and (iii) intra household food allocation which may obscure gendered disparities in access, especially given the study's focus on women’s roles.

To mitigate these concerns, the study standardized food intake using adult-equivalent units which helps adjust for household composition and was surveyed during a stable post-harvest season to minimize seasonal distortion. While not exhaustive, this approach provides a meaningful approximation of food access and energy sufficiency at the household level which aligns with the study's objectives.

b) Nutrition Security Status (HDDS)

Variation in a person's diet is closely linked to the adequacy of calorie and nutrient intake. Global nutrition guidelines emphasize dietary diversity as a key strategy to ensure sufficient intake of micronutrients, especially in populations whose diets are dominated by starchy staples and are prone to deficiencies. In such contexts, the Household Dietary Diversity Score (HDDS) is commonly used as a proxy for household-level nutrition security.

HDDS is calculated based on the number of different food groups consumed by household members over a reference period, typically 24 hours. It serves as a count-dependent variable and provides a simple yet effective means of capturing qualitative aspects of food consumption. This method has been widely validated and applied in low- and middle-income country settings (Swindale & Bilinsky, 2006; FAO, 2011) particularly where detailed nutrient intake data are not feasible to collect.

This study uses HDDS to reflect household nutrition security as it is well-suited to the rural context of Chakwal where households often rely on subsistence farming and lack dietary diversity. Moreover, HDDS is particularly appropriate for evaluating agricultural-nutrition pathways as it is sensitive to changes in food access and availability resulting from agricultural interventions. While HDDS does not measure nutrient adequacy directly, it offers valuable insights into the variety and quality of diets which are critical for understanding the role of women in ensuring household nutrition.

2.3.2. Independent Variables

Women Characteristics

a) Age

A woman's age may play an essential role in determining household food and nutrition security status. With growing age, women can better understand the food and nutritional needs of different age groups of households.

b) Education

The education status of women, both formal and informal, is an essential factor for achieving household food and nutrition security status. Women's education is defined as "the highest level of schooling attended in their lives". Women's education may play a significant role in understanding the food and nutritional needs of households.

c) Time Allocation to Pulse Production

In the pulse production of the Chakwal district, the time allocation of women plays an important role. We calculated the number of hours they spend on pulse-growing activities in a day. This time allocation could be paid or unpaid.

d) Time Allocation to Household Reproductive Activities

We calculated the number of hours they spend on household chores such as purchasing, preparing, and cooking food, caring for elders and children, washing pots, cleaning the house, washing clothes, etc., in a day.

e) Time Allocation to Leisure

How much time do women spend in a day on personal care, resting, watching TV, family visits, chatting with family members, etc.?

f) Women Empowerment

Women's ability to make decisions is an essential element that influences household food and nutrition security. Decision-making is measured in the form of an additive index. To assess women's decision-making autonomy, this study used four decision-making variables such as 1) decision-making in large household purchases, 2) decision-making in visiting family relatives, 3) decision-making in children's education, and 4) decision-making about health care. We assigned a score of 1 if women were involved either alone, with their partner, or with a relative, otherwise 0, against each empowerment question. The scores on these individual variables had been added, and a count variable was generated that takes the value between 0 and 4.

g) Assets Ownership

Asset ownership has numerous benefits for women, such as increasing the availability and accessibility of food to households. Assets are considered protection against financial shocks. We assumed ownership of small and large ruminants by women under asset ownership. This is also captured in the form of a count variable by adding the number of small and large ruminants.

2.4. Econometric Method

2.4.1. Women's Participation in the Pulses Production Model

To estimate the determinants of women's participation in pulse production (WP_i), the Tobit regression approach was employed. This choice is justified because the dependent variable, time allocated by women to pulse production is a non-negative, continuous variable that is left-censored at zero, i.e., some women in the sample reported zero hours of participation. In such cases, standard Ordinary Least Squares (OLS) regression can produce biased and inconsistent estimates due to censoring in the data distribution.

The Tobit model accounts for both the decision to participate and the amount of time allocated in a single framework. This makes it more appropriate than alternatives like a two-stage model combining a probit (participation decision) and an OLS (time allocation) approach which may treat these dimensions independently and overlook potential correlation in error terms.

To estimate the determinants of women's participation (WP_i) in pulse production, the Tobit regression approach was used as WP_i which is a continuous dependent variable with left censoring and is assumed to follow the Tobit distribution:

To estimate the determinants of women's participation in pulse production (WP_i), the Tobit regression approach was employed. This modeling choice is justified because the dependent variable time allocated by women to pulse production is a non-negative, continuous variable that is left-censored at zero. A significant portion of women in the sample reported zero hours of participation, indicating that censoring is present in the data.

In such cases, using Ordinary Least Squares (OLS) would be inappropriate, as it does not account for the censoring and would result in biased and inconsistent estimates. Although a two-stage modeling strategy combining probit regression (for participation decision) and OLS regression (for time allocation) could be considered, it treats the two decisions independently and ignores the potential correlation between the error terms in each stage.

The Tobit model, on the other hand, integrates both the participation decision and the intensity of time allocation into a single estimation framework. This approach corrects for the sample selection bias inherent in the two-stage method and accounts for the censoring at zero. Moreover, formal tests for censoring (e.g., the proportion of zero observations and likelihood

ratio tests comparing Tobit with OLS) confirmed that censoring was statistically significant in the sample, further supporting the appropriateness of the Tobit specification.

$$WP_i = \alpha_o + \gamma_0 W_i + \delta_0 H_h + \lambda_0 \mathrm{R}_r + \varepsilon_i \quad \text{--- (1)}$$

In eq. (1), α_o is the intercept term, γ_0 is a vector of coefficients of socio-economic characteristics of women such as age, education, allocation of time to reproductive activities and leisure, empowerment, asset ownership, and body mass index that influence women's physical efforts, δ_0 is a vector of coefficients of household-level determinants H_h such as family income and farming type, λ_0 is a vector of coefficients of regional tehsil dummies and ε_i is the error term.

2.4.2. Household Food Security Model

To estimate the impact of women's participation (WP_i) on household food security (FS_h), the ordinary least squares regression approach was used as s FS_h. It is a continuous dependent variable and is assumed to follow a normal distribution:

$$FS_h = \alpha_o + \beta_0 WP_i + \gamma_0 W_i + \delta_0 H_h + \lambda_0 \mathrm{R}_r + \varepsilon_h \text{ --- (2)}$$

In eq. (2), α_o is the intercept term, β_0 is the coefficient of rural women's participation in pulse production WP_i which is measured by time spent performing different pulse-related production activities. γ_0 is a vector of coefficients of socio-economic characteristics of women such as age, education, allocation of time to reproductive activities and leisure, empowerment, and asset ownership. δ_0 is a coefficient of a household-level determinant. H_h such as family income, λ_0 is a vector of coefficients of regional tehsil dummies and ε_h is the error term.

2.4.3. Household Nutrition Security Model

To estimate the impact of women's participation in pulse production on household nutrition security, the Poisson regression approach was applied. This method is appropriate when the dependent variable is a non-negative count variable, such as the Household Dietary Diversity Score (HDDS) which measures the number of different food groups consumed in a day. Poisson regression is based on the assumption of equidispersion where the mean and variance of the dependent variable are equal. Before model estimation, we conducted a diagnostic test for overdispersion using the Pearson chi-square dispersion statistic. The test results indicated that the dispersion parameter was close to 1, suggesting that the Poisson model assumptions were not violated. Therefore, the Poisson regression was deemed suitable for this analysis.

To estimate the impact of women's participation (WP_i) on household nutrition security, the (NS_h). The Poisson regression approach was used as NS_h which is a count-dependent variable and is assumed to follow a Poisson distribution:

$$NS_h = \alpha_o + \beta_0 WP_i + \gamma_0 W_i + \delta_0 H_h + \lambda_0 \mathrm{R}_r + \varepsilon_h \text{ --- (3)}$$

In eq. (3), α_o is the intercept term, β_0 is the coefficient of rural women's participation in pulse production WP_i which is measured by time spent performing different pulse-related production activities. γ_0 is a vector of coefficients of socio-economic characteristics of women such as age, education, allocation of time to reproductive activities and leisure, empowerment, and asset ownership. δ_0 is a coefficient of a household-level determinant H_h such as family income, λ_0 is a vector of coefficients of regional tehsil dummies and ε_h is the error term.

2.4.4. Two-Stage Least Squares (2SLS) Regression Approach

The feminization of agriculture places significant physical demands on women. Previous research suggests that healthier women particularly those with normal body mass index (BMI) are more likely to engage in labor-intensive agricultural activities (Pradeilles et al., 2019).

Likewise, women's agricultural involvement tends to increase in subsistence-farming households, where labor is often sourced internally (FAO, 2010). Given these relationships, women's time allocation to pulse production is considered an endogenous variable, potentially correlated with unobserved household characteristics that also affect food and nutrition security.

To address this endogeneity and obtain unbiased estimates, we employed the two-stage least squares (2SLS) regression method. Two instruments were used in the first stage: (i) women's body mass index (BMI) and (ii) the type of household farming (subsistence vs. commercial). Both instruments are theoretically justifiable: BMI proxies physical capacity for labor, and farming type captures structural household reliance on female labor for food production.

3. REGRESSION RESULTS AND DISCUSSION

3.1. Determinants of Rural Women's Participation in Pulses Production

The Tobit regression findings calculating the factors influencing rural women's involvement in pulse production are shown in Table 1. The results demonstrate how women's labor contributions in agriculture are influenced by their physical capabilities, asset control, and opportunity cost of time. First and foremost, physical and demographic traits are crucial. Women with larger body mass are less likely to do physically demanding agricultural jobs, according to the negative and highly significant coefficient of BMI. This finding supports earlier research that relates farm labor potential with physical fitness (Pradeilles et al., 2019). On the other hand, women's age had no discernible effect which may suggest that in this situation, time availability and health are more important factors than age alone when it comes to agricultural engagement. Another restriction that has a negative and statistically significant impact is educational achievement. This implies that women with higher levels of education could devote more of their time to non-agricultural tasks or domestic decision-making. This result is in line with research from comparable rural economies that shows a correlation between women's education and either less agricultural labor involvement or non-manual work (Naz et al., 2020).

The findings highlight the trade-offs of conflicting time uses, which is significant. The amount of time spent on agricultural output is inversely correlated with the amount of time spent on leisure and reproductive activities. The findings of Doss et al. (2020) and Rao & Raju (2020), which emphasize that women's household responsibilities restrict their involvement in productive labor markets, are echoed by the strong and significant coefficients for both which show the reality of poverty among rural women. Women's participation in pulse production is positively impacted by their access to and control over productive assets, as indicated by their ownership of animals. This result is consistent with the large body of research on women's empowerment and asset ownership which contends that having control over assets increases women's negotiating power and encourages them to participate more in activities that generate revenue from agriculture (Galie et al., 2019).

It's interesting to note that although participation was favorably correlated with women's empowerment measure (based on decision-making autonomy), the relationship was statistically insignificant. This implies that empowerment by itself, in the absence of concrete access to resources or time, would not result in real participation—a subtlety that is consistent with criticism of depending too much on measures related to decision-making to gauge agency (Ahmad & Khan, 2016).

The qualities of the household are also important. Despite being statistically significant, household income showed a small effect size, indicating that financial pressure might not be a powerful deterrent or motivator for involvement. Women's labor input was, however, greatly enhanced by the kind of farming (commercial vs. subsistence)- suggesting that families in

subsistence settings depend more on unpaid female labor to satisfy production demands; hence enhancing women's role as economic stabilizers in rural areas with limited resources (FAO, 2010). When taken as a whole, these results offer a complex picture of the social, economic, and structural barriers to women's involvement in agriculture. Rural women manage difficult trade-offs influenced by health, time management, education, and resource availability rather than working passively.

Table 1 presents the results of the Tobit regression used to explore determinants of rural women's participation in pulse production. The coefficient of women's BMI is negative and statistically significant at less than a 1% significance level. This implies that if women's BMI increases by 1 kg/m2, which is a sign of a healthy/unhealthy body then women's allocation of time to pulse productive tasks decreases by 0.19 hours per day. The significance of this instrument would help us control the endogeneity with women's allocation to agricultural productive tasks, and this instrument has been used because many studies reported that if a woman becomes overweight then her physical effort required for agrarian work would decline (Pradeilles et al., 2019).

The coefficient of women's age is positive but insignificant. It means that women's age has no significant impact on their Allocation of time to agricultural-related productive tasks.

The coefficient of women's education is negative and significant at a 1% significance level. This implies that if women's education increases by one year of schooling, women's time on agricultural-related productive tasks decreases by 0.08 hours per day.

The coefficient of reproductive hours is negative and statistically significant at less than a 1% significance level. The negative sign of this coefficient implies a competition between women's time on agricultural productive tasks and household-related reproductive tasks. However, if women's allocation to reproductive tasks increases by 1 hour per day then their allocation of time to agricultural productive tasks decreases by 0.19 hours per day.

Similarly, the coefficient of women's leisure hours is negative and statistically significant at a 1% significance level. This implies that if a woman's allocation of waking time to leisure hours increases by 1 hour per day then her time allocation to agricultural productive tasks decreases by 0.62 hours per day.

The coefficient of women owning small and large livestock is positive and statistically significant at less than a 5% significance level. If a woman holds small and large ruminants her allocation of time to agricultural productive tasks increases by 0.44 hours per day.

The coefficient of women's empowerment on four decisions is positive and statistically insignificant. This implies that women's empowerment on four essential questions: the decision of food, the decision to go outside, the decision of children's education, and the decision of clothing has no impact on women's allocation of time to agricultural productive tasks.

The coefficient of household monthly income is positive and statistically significant at a 1% level. However, its impact size is very negligible.

The coefficients of all the tehsil dummies are insignificant, implying no geographic variations in women's participation in pulse production. Results of the L.R. test indicate that the overall model is highly significant.

Table 1: Determinants of Rural Women Participating in Pulses Production (Tobit Regression)

Variable	**Coefficient**	**Standard Error**	**P-Value**
Women's Characteristics			
Body Mass Index (kg/m^2)	-0.188***	0.029	0.000
Age (years)	0.011	0.107	0.301
Education (years)	-0.075***	0.027	0.008

Allocation of time to household reproductive tasks (hours/day)	-0.188***	0.064	0.004
Allocation of time to leisure (hours/day)	-0.619***	0.082	0.000
Asset ownership (No.)	0.460***	0.175	0.010
Women's empowerment (No.)	0.029	0.099	0.769
Household's Characteristics			
Income (Rs/month)	0.000***	7.54e	0.002
Pulses are grown for subsistence vs commercial purposes (=1, otherwise 0)	0.667**	0.333	0.048
Lawa tehsil [a]	0.470	0.463	0.312
Talagang tehsil [a]	-0.077	0.435	0.859
Chakwal tehsil [a]	0.159	0.450	0.724
Intercept	11.237***	1.156	0.000
Model Stat			
Observations	120		
LR Chi^2 (12)	150.29***		
P-value of Chi^2	0.000		
Pseudo R^2	71.37%		

***, **, * Significant at 1%, 5% and 10% level, respectively. Data Source: A.C.I.A.R. (Australian Center for International Agricultural Research) Pulses Project (2021)

3.2. Impact of Rural Women's Participation in Pulses Production on Household Food Security

The results of the impact of women's participation in pulse production on household food security are reported in Table 2. Among the demographic variables of women, the coefficient of women's age is positive and statistically significant at less than a 5% significance level. This implies that with an increase in women's age, calorie consumption increases by 10.78 kilocalories per adult equivalent per day. This could be because, with age, women's understanding increases to meet energy requirements for different age groups in a household. Women's roles changed with the change in age. According to Emily et al. (2017), young women are more engaged in food production and usage while elderly females are more engaged in food decision-making and capital control.

Among women's time variables, the coefficient of women's allocation of time to pulse production activities is positive and statistically significant at less than a 1% level of significance. If a woman allocates one additional hour to pulse production tasks, calorie consumption increases by 186-kilo kilocalories per adult equivalent per day. This is because when women spend more time in agricultural work, they earn more income or secure more food, ultimately benefiting their household to achieve food security. According to Jensen et al. (2010), women's revenue-generating activities improved family food security and reduced malnutrition. Women's income was significant for long-term food consumption in low-income households.

If a woman is increasing 1 hour of her labor work to reproductive tasks then calorie consumption rises by 63 kilocalories per adult equivalent per day. Increased allocation of women to reproductive chores leads to a 63 kcal/A.E./day increase in calorie consumption. Women's reproductive activities, particularly family care and food preparation, are critical to the household's healthy functioning. Rural women devote a significant percentage of their time to domestic duties which demonstrates that reproductive duties in Pakistan remain a female sector. This finding aligns with third-world studies (Rao & Raju, 2020). However, women's reproductive labor is rarely acknowledged as real work. Women's time, on the other hand, is seen to be boundless (Doss et al., 2020).

However, women's participation in agricultural work has increased calorie consumption by three times that of nonagricultural work. This is because agricultural work provides payments to women in cash and in-kind which could help overcome household financial constraints to food security. In reproductive tasks, women are responsible for most home and child-raising chores and the nurturing of small animals. Ellis et al. (2012) reported in their study that women are often less able to engage in economic possibilities than males. Women are responsible for most home and child-raising chores and nurturing small animals. However, conventions vary by culture and throughout time. This unpaid job burden limits women's ability to engage in income-generating activities which frequently needs a set amount of time to be profitable. However, women's leisure hours do not significantly impact household food security.

Among household-level socioeconomic variables, the coefficient of household monthly income is positive and statistically significant at less than a 1% significance level. This implies that with an increase in household income, the calorie consumption of household members increases. However, the size of this coefficient is minimal. As described in previous studies, food insecurity is more widespread among low-income households.

The coefficient of asset ownership is positive and statistically significant at less than a 5% significance level. This coefficient elaborates that if women's ownership of livestock increase then food consumption increases by 195 kilocalories per adult equivalent per day. Talukder et al. (2010) also reported the same results.

We measured women's empowerment by using four questions of decision-making. The decision of food for household members, the decision of clothes, the decision of child education, and the decision of outdoor visits. This positive and statistically significant coefficient indicates that women's empowerment increases food consumption by 115-kilo kilocalories per adult equivalent per day. Amongst geographical variables, the coefficients of all three tehsil dummies are statistically insignificant. This indicates that calorie consumption is almost the same in these tehsils. This is because of the exact location, crops, and weather. Tehsil Taman is used as a control category.

Table 2: Determinants of Household Food Consumption

Variable	**Coefficient**	**Standard Error**	**P-Value**
Women's Characteristics			
Age (years)	10.78**	4.76	0.02
Education (years)	6.92	12.58	0.58
Allocation of time to agricultural productive tasks (hours/day)	186.4***	34.98	0.00
Allocation of time to household reproductive tasks (hours/day)	62.81**	29.92	0.03
Allocation of time to leisure (hours/day)	31.17	44.29	0.48
Asset ownership (No.)	194.64***	79.76	0.01
Women's empowerment (No.)	114.90***	43.98	0.01
Household's Characteristics			
Income (Rs/month)	0.02***	0.00	0.00
Lawa tehsil [a]	96.16	195.2	0.62
Talagang tehsil [a]	107.5	183.0	0.55
Chakwal tehsil [a]	-14.58	188.2	0.93
Intercept	-480.0	462.2	0.30
Model Stat			
Observations	120		
F-stat	26.37***		
P-value of F-stat	0.00		

R-square	74.73%
Adjusted R-square	71.89%

***, **, * Significant at 1%, 5% and 10% level, respectively. Data Source: A.C.I.A.R. Pulses Project (2021)

3.3. Impact of Rural Women's Participation in Pulses Production on Household Food Security after Controlling for Endogeneity

3.3.1. Results of the First Stage of Instrumental Variable Regression

The coefficient of women's B.M.I. is negative and statistically significant at less than a 1% significance level (Table 3). This implies that if women's BMI increases by 1 kg/m2, which is a sign of increased body fat then women's allocation of time to agricultural productive tasks decreases by 0.19 hours per day. The significance of this instrument would help us control the endogeneity of women's practical agrarian work. This instrument has been used because many studies reported that if a woman becomes overweight then the physical effort required for agricultural tasks declines (Pradeilles et al., 2019).

The coefficient of women's education is negative and significant at a 1% significance level. This implies that if a woman's education increases by one year of schooling then her time on agricultural-related productive tasks decreases by 0.07 hours per day.

The coefficient of reproductive hours is negative and statistically significant at less than a 1% significance level. The negative sign of this coefficient implies a competition between women's time on agriculture-productive tasks and household-related reproductive tasks. However, if women's allocation to reproductive tasks increases by 1 hour per day then their allocation of time to agricultural productive tasks decreases by 0.18 hours per day.

Similarly, the coefficient of women's leisure hours is negative and statistically significant at a 1% significance level. This implies that if a woman's allocation of waking time to leisure hours increases by 1 hour per day then her time allocation to agricultural productive tasks decreases by 0.62 hours per day.

The coefficient of women owning small and large livestock is positive and statistically significant at less than a 5% significance level. If a woman owns small and large livestock then her allocation of time for agricultural productive tasks which covers her time for pulses farming and managing the small and large livestock increases by 0.44 hours per day.

The coefficient of household monthly income is positive and statistically significant at a 1% significance level. If household income increases by 1 Rs per month then women's allocation of time to agricultural productive tasks increases by 0.00 hours per day. However, the size of this coefficient is minimal implying that the impact of household income is not dominant in our case.

The coefficient of household production of pulses for household consumption is positive and statistically significant at less than a 5% significance level. This implies that if households decide to produce pulses for home production then women's allocation of time to agricultural productive tasks increases by 0.67 hours per day. This implies that women are significant in producing pulses for home consumption. In the Chakwal region, pulses are the women's crop grown by the household on the marginal and small land. Poor women are dominant here because they feel that if they can care for this crop then they can produce household food. In this region, women are growing the pulses, splitting the grain, and making dal and gram flour. The coefficients of the tehsil districts are insignificant implying that women's allocation of time to agricultural productive tasks is almost the same in these districts.

Table 3: Results of the First Stage of Instrumental Variable Regression

Variable	Coefficient	Standard Error	P-Value
Women's Characteristics			
B.M.I.	-0.190***	0.031	0.000

Age (years)	0.011	0.011	0.325
Education (years)	-0.074***	0.029	0.012
Allocation of time to household reproductive tasks (hours/day)	-0.180***	0.066	0.008
Allocation of time to leisure (hours/day)	-0.618***	0.087	0.000
Asset ownership (No.)	0.442**	0.186	0.020
Women's empowerment (No.)	0.028	0.106	0.794
Household's Characteristics			
Income (Rs/month)	0.000***	7.54e	0.002
Pulses grown for subsistence vs commercial purposes (%) (=1, otherwise 0)	0.667**	0.333	0.048
Lawa tehsil [a]	0.470	0.463	0.312
Talagang tehsil [a]	-0.077	0.435	0.859
Chakwal tehsil [a]	0.159	0.450	0.724
Intercept	11.19***	1.221	0.000
Model Stat			
Observations	120		
F-stat	22.23***		
P-value of F-stat	0.000		
R-square	71.37%		
Adjusted R-square	68.16%		

***, **, * Significant at 1%, 5% and 10% level, respectively. Data Source: A.C.I.A.R. Pulses Project (2021)

3.3.2. Results of the Second Stage of Instrumental Variable Regression

After controlling for endogeneity, the unbiased results of the household food security model are presented in Table 4. The coefficient of women's age is positive and statistically significant. This implies that with increased women's age, calorie consumption increases by 12.37 kilocalories per adult equivalent per day. This could be because women become more skilled in managing household cooking chores, particularly preparing food for different age groups. Women's roles change with the change in age. Young women are more engaged in food production and usage, and elderly females in food decision-making and capital control (Doss et al., 2020).

Among women's time variables, the coefficient of women's allocation of time to pulse production activities is positive and significant. Moreover, this result of women's time allocation to Agri work is more consistent because we have controlled endogeneity in this variable using two unique instruments in the first stage of instrumental variable regression, given in Table 3. If a woman allocates one additional hour to pulse production tasks, calorie consumption increases by 102.3 kilocalories per adult equivalent per day. This is because when women spend more time in agricultural work, they earn more, ultimately benefiting their households. Economically active women are more productive which improves their food security. Only 23% of women are employed in a wage-earning capacity worldwide (Jensen et al., 2010).

If a woman is increasing 1 hour of her labour work to reproductive tasks then her calorie consumption increases by 52.78 kilocalories per adult equivalent per day. Increased allocation of women to reproductive chores leads to a 52.78 kcal/A.E./day increase in calorie consumption. Women's reproductive activities, particularly family care and food preparation, are critical to household's healthy functioning. Rural women devote a significant percentage of their time to domestic duties, demonstrating that reproductive duties in Pakistan remain a female sector. This finding aligns with third-world studies (Picchioni et al., 2020). However, women's leisure hours

do not significantly impact household food security. In their leisure time, women are not doing any productive or reproductive activity.

The coefficient of asset ownership is positive and statistically significant. This coefficient elaborates that when women's ownership of small livestock increases then food consumption increases by 0.02% kilocalories per adult equivalent per day. Galie et al. (2019) also reported the same results.

Among the socioeconomic variables, the coefficient of household monthly income is positive and statistically significant at less than a 1% significance level. This implies that with an increase in household income the calorie consumption of household members increases.

Amongst geographical variables, the coefficients of all three tehsil dummies are statistically insignificant. This indicates that calorie consumption is almost the same in these tehsils. This is because of the exact location, crops, and weather. Tehsil Taman was used as a control category.

Table 4: Results of the Second Stage of Instrumental Variable Regression (H.F.S.)

Variable	Coefficient	Standard Error	P-Value
Women's Characteristics			
Age (years)	12.37***	4.538	0.006
Education (years)	-4.725	13.20	0.720
Predicted Allocation of time to agricultural productive tasks (hours/day)	102.3*	60.03	0.088
Allocation of time to household reproductive tasks (hours/day)	52.78*	29.26	0.071
Allocation of time to leisure (hours/day)	-4.416	57.30	0.939
Asset ownership (No.)	295.3***	83.59	0.000
Women's empowerment (No.)	125.9***	41.92	0.003
Household's Characteristics			
Income (Rs/month)	0.030***	0.003	0.000
Lawa tehsil [a]	181.7	186.9	0.331
Talagang tehsil [a]	135.6	169.1	0.423
Chakwal tehsil [a]	20.38	175.2	0.907
Intercept	0.345***	574.7	1.000
Model Stat			
Observations	120		
Wald-stat	333.1		
P-value of Wild-stat	0.000		
R-square	74.77%		

***, **, * Significant at 1%, 5% and 10% level, respectively**.** Data Source: A.C.I.A.R. Pulses Project (2021)

3.4. Impact of Rural Women's Participation in Pulses Production on Household Nutrition Security after Controlling for Endogeneity

Table 5 presents the results of the household nutrition security model using the Poisson regression approach and after correcting for endogeneity.

Among women's time variables, the coefficient of women's allocation of time to pulse production activities is positive and significant. If a woman allocates one additional hour to pulse production tasks, then the household dietary diversity score increases by 4.2%. This is because when women spend more time in agricultural work, they earn more income/food- ultimately benefiting their households in securing diverse foods. Economically active women are more productive which improved their dietary diversity.

If a woman increases 1 hour of her labour work to reproductive tasks, then household nutrition security increases by 2.3%. Increased allocation of women to reproductive chores leads

to 2.3% more diverse diets/day. Women's reproductive activities, particularly family care and food preparation, are critical to household's healthy functioning. Rural women devote a significant percentage of their time to domestic duties, demonstrating that reproductive duties in Pakistan remain a female sector. This finding aligns with third-world studies (Picchioni et al., 2020).

The coefficient of asset ownership is positive and statistically significant. If a woman has agricultural assets and minimal and large livestock, then the coefficient elaborates that the dietary diversity score increases by 5.7% per day. Qaim & Kouser (2013) also reported the same results.

Amongst socioeconomic variables, the coefficient of household monthly income is positive and statistically significant at less than a 1% significance level. This implies that with an increase in household income the calorie consumption of household members increases. Among geographical variables, the coefficients of all three tehsil dummies are statistically insignificant. This indicates that dietary diversity is almost the same in these tehsils. This is because of the exact location, crops, and weather. Tehsil Taman is used as a control category in this analysis.

Table 5: Results of the Second Stage of Instrumental Variable Regression (HDD)

Variable	**Coefficient**	**Standard Error**	**P-Value**
Women's Characteristics			
Age (years)	0.002	0.002	0.469
Education (years)	0.000*	0.008	0.089
Predicted Allocation of time to agricultural productive tasks (hours/day)	0.042*	0.040	0.090
Allocation of time to household reproductive tasks (hours/day)	0.023*	0.020	0.060
Allocation of time to leisure (hours/day)	0.011	0.376	0.762
Asset ownership (No.)	0.057*	0.535	0.085
Women's empowerment (No.)	0.009**	0.027	0.042
Household's Characteristics			
Income (Rs/month)	3.94e**	1.83e	0.031
Lawa tehsil [a]	-0.789	0.120	0.512
Talagang tehsil [a]	-0.021	0.106	0.842
Chakwal tehsil [a]	-0.029	0.111	0.793
Intercept	1.206***	0.391	0.002
Model Stat			
Observations	120		
LR-stat	26.44		
P-value of LR-stat	0.005		
R-square	5.36%		

***, **, * Significant at 1%, 5% and 10% level, respectively**.** Data Source: A.C.I.A.R. Pulses Project (2021)

4. CONCLUSION AND POLICY RECOMMENDATIONS

Women are essential in agricultural and nonagricultural activities, especially harvesting, post-harvesting, livestock, poultry rearing, etc. Economic pressure forces them to break away from their traditional roles as homemakers into farm and non-farm laborers. The findings of our paper disclosed that the contribution of female labor in different activities is significant. Participation of rural women is apparent in diverse forms of agricultural and nonagricultural activities. In the case of farming activities, women laborers are mainly involved in harvesting and post-harvesting activities. In the case of nonagricultural activities, the contribution of women's labor is highest for household chores like home cleaning, cooking food, taking care of children and elders, and other farm activities. The most crucial factor for women seeking

employment or involvement in many activities is to meet family needs, followed by increasing family income.

The study found that in terms of household food availability, most rural households accomplish their dietary food requirements from their cultivation. Women are primarily responsible for maintaining food stocks and household storage using their indigenous knowledge for household food availability. Women's income improves the household's capacity to sustain suave consumption and dietary diversity in times of vulnerability and shortage. The study also revealed that income in the hands of women improves not only household food consumption and dietary diversity but also the probability of being food-secured. Furthermore, women's decision-making power improves household food security status, food consumption quality, and dietary diversity. Public awareness programs on healthy food and a balanced diet should be developed in rural regions.

Policies regarding the government of Pakistan should focus on the participation of rural women in productive activities to ensure family food security. Agricultural innovations should encourage women's involvement in food crop production as producers, laborers, and processors. The provision of small-scale income-generating opportunities at home or near home may not affect their time for household tasks. Furthermore, boosting rural women's nutritional knowledge and awareness is critical. In rural regions, public awareness programs on healthy food and a balanced diet should be developed.

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