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Adoption of Climate Smart Agricultural Practices through Women Involvement in Decision Making Process: Exploring the Role of Empowerment and Innovativeness

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Abstract: The sustainability of global food production has been facing many threats, including climate change. The adaptation to such threats is both a challenge as well as an opportunity, especially for woman-operated farms in Pakistan. The challenge is how to devise measures and look for options to counter its impact, while the opportunity lies in developing new techniques, skills, and interventions leading to innovativeness. As women farmers are constrained regarding resources, cultural, societal, and personal reasons in Pakistan's context, they particularly need innovative behavior and decision power to adapt to climate change. This study aims to measure the decisional empowerment and innovativeness of women farmers and their role in adopting different climate-smart agricultural (CSA) practices at the farm level. To this end, data from 384 farms where women were majorly involved are utilized in a multivariate probit model and propensity score matching to reveal various aspects of women's role in adopting CSA practices. Results reveal that most women farmers lacked decisional power related to productive resources such as sale/purchase and renting of farmland, using farm machinery, and availing credit. Their decisional empowerment and innovativeness positively affected the adoption of CSA practices at the farm level. Females with more decisional power and innovativeness adopted more CSA practices than women with weaker decisional power and innovativeness. Therefore, the world can benefit greatly from giving more power to women in agriculture in terms of increased adoption of CSA practices, consequently improving food security and mitigating climate change. This outcome will assist in achieving the United Nation's Sustainable Development Goals of gender equality (SDG5) and climate action (SDG 13).

Keywords: women participation; poverty; equity; decision support; technology; wellbeing

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1. Introduction

Agricultural food systems play a crucial role in sustainable development, but the sustainability of agri-food systems is threatened by changing circumstances, including climate change. The climate of planet earth has changed during the past centuries due to a surge in greenhouse gases (GHG) mainly attributed to human activities. Climate change directly impacts rainfall, temperature, availability of water, and soil quality, which are fundamentals for sustainable agricultural production. Failure to adapt to changing climate conditions results in lower agricultural productivity, which negatively affects food security and economic growth [1,2]. Adopting climate-smart agricultural practices (CSA) can support the farming community in minimizing the impact of climate change on agriculture [3]. Despite considerable efforts and investments to enhance CSA in developing countries, the adoption of CSA practices remains low at the farm level in these countries. Nonetheless, The CSA plays a critical role and is recommended as a significant element in the growth of the agricultural sector [4]. Adopting CSA is also central to maintaining agricultural productivity under a changing climate and decreasing GHG emissions, which is necessary at the farm level [5].

Gender, decision-making power, and innovativeness of the farm managers play central roles in selecting different farm practices and CSA strategies. Like other facets of human life, decision-making at the farm level is also not gender-neutral. Decision-making is grounded on preferences, and women and men farmers have different priorities and preferences in agriculture [6]. Men farmers tend to cultivate crops with high market demand and yield more profit than women [7]. Moreover, the rational behavior of farmers in confronting risks depends on the decision-making power of the farm managers [8]. Males dominate decision-making in agricultural activities, but the role of women in decision-making is also increasing in developing countries [9]. Furthermore, the agricultural industry can route the future with the help of responsible innovation [10]. Gender role in innovation is an influential imperative factor in innovation, and the role of women in innovation has been augmented in recent years, though there is still a substantial gap between male and female innovators [11].

Women farmers are disadvantaged relative to male farmers [12,13]. Women farmers in developing countries lack financial capital and access to productive resources [14]. Moreover, societies in the developing world do not permit females to communicate for their privileges, predominantly farmland proprietorship. Guaranteeing rights equivalent to males concerning water, land, income, and other resources could generate prolific results in sustainable agricultural productivity [15]. In developing countries, although they confront tenacious social hindrances and economic restraints, women play an influential role in agricultural growth [16]. Regardless of all these hindrances, women's share of food production is more than 50% worldwide [17], and the role of women in agriculture cannot be denied because 36.7% and 43.6% of the agricultural labor force of developed and underdeveloped countries respectively consisted of women in agriculture [18].

Thus, women farmers have a pivotal role in ensuring global food security and the rural development of developing countries [19]. Women own one-tenth to one-fifth of global agricultural land [20,21], and women are likely to be more affected by climate impacts than men, especially in developing countries where their involvement in agriculture is high [22,23]. Therefore, the adoption of CSA practices is necessary to minimize climate impacts. Adoption of CSA at the farm is not gender neutral, and researchers need to understand the role of gender in CSA adoption on farms [24]. They also described that woman farmers are more likely than or just as likely as men to adopt CSA practices when information on climate changes is available to them. [25] also stated that female farmers are likelier to adopt CSA practices than males on their farms. It has been projected that if rural women had access to and control over agricultural resources equal to males, yields might improve by 20–30%, while the overall number of hungry people worldwide would decrease by 12–17% [26], Ref. [27] also stated that giving more control of productive resources and decisional power regarding the management of the farm can improve CSA adoption on their farms. [28,29] reported that households where women are more empowered tend to be more open to adopting new CSA practices.

Abundant literature is available on the adoption of CSA at the farm level. Still, only a few studies are available on the adoption of CSA at the farm level in the context of decisional empowerment and innovativeness of women farmers. Therefore, this study aimed to measure the decisional empowerment and innovativeness of women farmers and their role in adopting CSA practices at the farm level. Moreover, the study also makes an effort to reduce gendered gaps in studies related to the adoption of CSA on farms. Until now, almost all literature on CSA worldwide has focused only on male farms.

This study considered Pakistan as a case study to represent the developing world. Pakistan is the 6th most populous developing nation in the world, and almost two-thirds of the Pakistani women are employed in the agriculture sector [30]. More importantly, women farmers in Pakistan also confront similar hindrances as faced by women farmers in other developing countries [31]. In the past, women's rights have been cramped in Pakistan, and the country ranked very low in the global gender equality index [32]. International commitments were made by Pakistan to slender the discrepancies and gaps between females and males and to ensure enhancement in women's privileges, such as the Beijing platform for action, sustainable development goals, universal declaration of human rights, and the convention on the elimination of all forms of discrimination against women, but at a worldwide level, Pakistan has ranked lower in gender equivalence. Additionally, there are cultural and societal prohibitions in Pakistan that reduce the accessibility of rudimentary rights to females [15]. Traditionally, Pakistani women have been retained away from the agricultural decision-making process. But now, the situation is changing in Pakistan, and the role of women farmers is also shifting from unpaid family labor to main decision-makers at the farm level. Moreover, feminization in farming is also growing due to the movement of males to cities for off-farm employment and the increased use of machinery at the farm level [33].

1.1. Theoretical Background on Climate-Smart Agriculture (CSA) and Women Empowerment

1.1.1. Climate-Smart Agriculture (CSA)

CSA is essential for economic development, food security, environmental sustainability, and conservation of ecosystems in developing countries. CSA has three main attributes: (1) enhanced agricultural productivity and income; (2) improved farm resilience against climate change, and (3) decreased GHG emissions from agriculture. CSA refers to several practices and technologies intended to enhance this "triple win" [34,35]. Different practices included under the CSA group can vary according to the geographical area and climatic conditions, but crop rotation covers crops, intercropping, new seed varieties, agroforestry, conservation tillage, livestock manure, and water conservation, commonly adopted CSA strategies at the farm level [36–40].

Crop rotation is the cultivation of different types of crops sequentially in the same field. Crop rotation is one of the important agricultural strategies for maintaining soil fertility, combating pests, obstructing weeds, and preventing soil-borne diseases [41]. Cultivation of a single crop in one field consecutively deteriorates soil quality due to continuous usage of the same nutrients. Cover crops are primarily grown to maintain soil health by preventing soil erosion and suppressing pests and weeds. Moreover, cover crops can feed animals through grazing and provide a living place for beneficial insects. Cover crops also fix atmospheric nitrogen and reduce nutrient leaching [42]. Human health and the increasing world population need stable food supplies with a healthy environment and sustainable ecosystems [43]. Well-designed intercropping can assist in overcoming the productivity challenges with limited resources. Intercropping is the cultivation of two or more crops simultaneously in one field. It uses natural resources efficiently, improves crop productivity and biodiversity, minimizes pest attacks, and improves soil quality and farm profit with lower use of off-farm inputs [44]. Usage of new high-quality seed varieties is a gateway to better yield, nutrition, and food security not only for the farmers but the whole world. New, improved seed varieties of different crops are also essential to use scarce natural resources efficiently and minimize climate change impacts on agriculture, as this sector is the basis of sustainable rural development [45]. Agroforestry is considered a significant land management strategy that utilizes natural resources efficiently. Agroforestry is the integration of woody vegetation (trees and shrubs) into the farming system. These trees and shrubs can be within or around the crops. Farming systems with agroforestry practices provide more ecosystem services (soil erosion reduction, enhanced carbon sequestration, and improved landscape biodiversity) than agroforestry-less farming systems [46]. Tillage-based agriculture has detrimental effects on natural resources (soil, water, biodiversity, and provision of ecosystem services). The negative effect of tillage on natural resources has caused agricultural productivity to decline and has promoted an essence among farmers to shift to alternative management practices like no-till or reduced tillage [47]. No-till or reduced till farming is the cultivation of crops that decreases soil erosion and helps maintain soil fertility. Extensive usage of mineral fertilizers not only causes climate change but also decreases farm profit as mineral fertilizers are expensive. Livestock manure contains crucial plant nutrients such as N, P, and K. In addition, livestock manure provides organic matter that can improve water holding capacity and increase soil carbon of agricultural land [48]. Water availability is the fundamental requirement for good crop yield, and water conservation is a key to sustainable food production in developing countries. Water conservation allows efficient use of water, resulting in increased crop productivity and farm resilience to droughts helping to improve the livelihood and food security of rural people. Adoption of different combinations of CSA strategies maximizes the synergies at the farm level and enables farmers to overcome overlapping challenges of social, economic, and environmental sustainability [38].

Suffice to say that all these CSA practices help improve agricultural productivity, minimize off-farm input usage (mineral fertilizer, pesticides, and weedicides), and increase the range of ecosystem services that leads to enhanced social, economic, and environmental sustainability. Moreover, the adoption of the CSA practices can assist governments in developing countries in achieving the United Nation's Sustainable Development Goals (SDGs) of no poverty (SDG 1), zero hunger (SDG 2), and climate action (SDG 13), which are impossible to achieve without adoption of CSA at farm level due to two main reasons: (1) Majority of the population in developing countries still live in rural areas, and agriculture is their main source of livelihood; (2) Agriculture has a one-third share in GHG emissions.

1.1.2. Adoption of CSA—Women Empowerment and Innovative Behavior

Adoption and diffusion of new innovative strategies and technologies in agriculture at the farm level are generally explained through different theories. The first theories consider the characteristics (comparative advantage and trialability) of innovations in explaining the adoption and diffusion process [49]. The relevant factors in these theories explain that the adoption and diffusion process are learning and initial investment cost, and extra inputs are required to adopt innovations [50]. Second, scientists use theories like the theory of planned behavior (TPB) to link the intentions and behavior of individuals to the adoption of innovations [51]. Third, theories take into account the expected utility of adopting innovation and also account for different resource constraints [52]. These adoption and diffusion theories do not consider the cognitive traits of farmers that may obstruct the adoption process [53].

Comparative to the above-discussed theories, we assume women farmers as price takers and active decision-makers in this study. We argue that women farmers keep changing their farming systems according to the changing business circumstances (social, economic, and environmental). Women farmers need innovative behavior and decision-making power to adapt to changing circumstances, including climate change.

Decision-making is one of the most important components of a farm manager's responsibilities, becoming more important under changing climate. Women's access to farm resources positively contributes to the implementation of CSA [54]. Moreover, women contribute more than 50% of the agricultural labor force in developing countries, but women farmers are comparatively disadvantaged compared to male farmers in controlling productive resources (land, animals, credit, and farm machinery) [55]. Women farmers' limited access and control over physical and human capital affect their livelihood [56] and capacity to adopt different CSA practices at the farm level. Irrespective of the context under consideration, CSA adoption signifies the role of adaptive capacity, which depends on the decision-making power related to the usage of productive resources and innovativeness of the women farmers [57,58]. Therefore, the adoption of CSA at women's farms can be explained by the decision-making power and innovativeness of the women farmers. We hypothesize that:

Hypothesis 1. *Women empowerment in decision-making related to agriculture is likely to positively influence the adoption of CSA.*

We also presume that

Hypothesis 2. *Women farmers with more decisional power are expected to adopt more CSA strategies.*

Innovativeness is the divergence from currently adopted technology and business practices to support new ideas often learned through experimentation [59]. Innovativeness is the key to adapting to climate change [60]. For women farmers, innovativeness may be adopting CSA practices at their farms to minimize climate change impacts. Therefore, we hypothesize that:

Hypothesis 3. *Innovativeness of women farmers is likely to positively influence the adoption of CSA practices.*

Additionally, we expect that

Hypothesis 4. *Women farmers with more innovativeness are expected to adopt more CSA strategies.*

2. Materials and Methods

2.1. Sampling and Data Collection Instrument

The target population were the women farmers residing in the Punjab province of Pakistan, which has the major share of agricultural production in the country. The province is more developed regarding employment opportunities for women and has a more female population relative to any other province in the country [61]. Moreover, fertile land and suitable climatic conditions of the province also provide women farmers a chance to participate in agricultural activities and rural development. The accessible sample of 384 women farmers was estimated by [62]'s formula:

$$n = \frac{X^2 * N * P * (1 - P)}{d^2 * (N - 1) + (X^2 * P * (1 - P))}$$

where

n = sample size
X^2 = Chi-square for specified confidence level at 1 degree of freedom (3.841)
N = population (Total households in Pakistan)
P = population share (Assumed 0.50 here)
d = sampling error (5% in this study)

The data were collected from farms that were either run by women solely or where their say in farming decisions was given weight, using multistage purposive and simple random sampling techniques through a personal interview survey. A well-designed data collection instrument consisting of three main parts was prepared by considering ground realities and previous studies on adopting CSA practices at the farm level, both at national and international levels. The first part of the data collection instrument contained questions related to the demographic characteristics of women farmers. The second part entailed questions related to the adoption of CSA practices. The third part of the questionnaire aimed to measure the decisional power and innovativeness of women farmers in agriculture through different five-point Likert scale questions. The questionnaire was validated through a preliminary study with 15 women farmers, and a few questions were amended to make it suitable to the ground realities of the study area.

2.2. Categorization of CSA Practices and Dependent Variable

Due to the wide range of farm-level CSA activities across locations, it is challenging to comprehend adoption trends in general, and adoption estimates in particular [63]. This explains why most assessments of CSA adoption and estimations of adoption advantages like resilience have not been applied outside of local contexts [64,65]. More conceptual clarity on farm-level CSA activities is thus needed to enhance adoption estimates and their comparability across contexts. This analysis may help clarify what counts as a CSA activity at the farm level and logically classify such activities in line with resource requirements. This kind of conceptual clarity could help move knowledge forward by connecting research on the dynamics of CSA adoption with current research on how farmers make decisions and how new ideas spread.

A typology is lacking in the current conceptual work that defines and provides broad analytic frameworks for CSA, making it difficult to investigate the many farm-level CSA activities. [38,57,66] are a few examples of previous analyses of CSA adoption that often use broad categories like diversification, soil and water conservation, and erosion control without classifying farm-level practices into a typology.

While developing typology assists in understanding the determinants and obstacles of CSA implementation at the farm level, we also recognize limitations like the difficulty of including different practices in distinct groups [67]. We overcome this difficulty by determining the resource that is an absolute necessity for adopting practice and without which the strategy cannot be adopted at women's farms. This way of categorizing has also been adopted in a study by [68] conducted in Malawi. Thus, a total of eight CSA practices were categorized into three groups, as shown in Table 1, which were used as the dependent variable for further analyses in the study.

Table 1. Categorization of CSA practices.

CSA Practice	CSA Groups		
	Unskilled Labor	**Skilled Labor**	**Financial Capital**
Crop rotation		✔	
Bed raising			✔
Cover cropping		✔	
Livestock manure	✔		
Conservation tillage		✔	
Intercropping	✔		
New seed varieties			✔
Agroforestry			✔

✔ indicates a resource that is an absolute necessity for adopting a practice.

The CSA practices were categorized into three broader groups based on the main resource required to adopt these practices at the farm level. The first CSA group includes those practices that need extra unskilled labor. This group requires women farmers to execute basic agricultural tasks (irrigation and input application). The CSA practices included in the second group require information, awareness, and skills to adopt these strategies at the farm level, in addition to the resources required for implementing CSA strategies in the first group. The CSA practices included in the third group require financial capital in addition to the resources required for CSA practices in the first and second groups to adopt these strategies at women's farms.

2.3. Econometric Procedure and Analytical Technique

Farmers are well aware of climate change and its impacts on agriculture and the ecosystem in developing countries [3]. Therefore, they are adopting different CSA practices to adapt to climate changes at the farm level. Women farmers also have a set of CSA strategies to select from to minimize the negative effects of climate change on their farms. Women farmers can implement a single or group of CSA strategies according to their ability, skill, resources, innovative behavior, and decisional power to adapt to climate changes.

Thus, we have the choice to analyze the underlying determinants of the adoption of CSA practices either through univariate or multivariate probit (MVP) econometric models. As in this study, women farmers have the choice to adopt different combinations of CSA practices at any given time; therefore, we used the MVP model to determine the factors affecting the adoption of different CSA combinations at women's farms in which disturbance terms freely correlate.

The MVP model used in the study contained three dummy variables to represent the different combinations adopted by the women farmers at their farms. The MVP econometric model is characterized by a set of dummy variables k that is 1 only if a woman farmer adopts any of the practices from the CSA combinations and 0 otherwise written as follows [38,69]:

$$Y_{ik}^{*} = X_i\beta_k + DM_i\beta_j + I_i\beta_s + e_{ik}\ k = 1\ldots\ldots\ldots\ldots 3 \tag{1}$$

where

$$Y_k = \begin{cases} 1,\ If\ Y_{ik}^{*} > 0 \\ 0,\ otherwise \end{cases}\ k = 1\ldots\ldots\ldots..3 \tag{2}$$

X_i = woman farm household background (demographic, institutional, and financial factors)

DM_i = decision-making power of women farmers

I_i = Innovativeness of women farmers

β_k,β_j,β_s = parameters

e_{ik} = disturbance term.

In Equation (1), we assume that an ith woman farmer has a latent variable Y_{ik}^{*} which shows the unobserved preference related to the kth choice of CSA combination. In literature related to the adoption of CSA at the farm level, it has been shown that implementing CSA strategies is constrained by different demographic, institutional, and environmental factors [69]. Therefore, we also assume that the choice of latent variable Y_{ik}^{*} is influenced by observable women household characteristics, decisional power, and innovativeness of women farmers. The women's household characteristics were categorized as human capital, institutional, and financial and physical capital. The human capital included age, education, farming experience, family size, and family type of women farmers. The institutional category included factors like extension services and internet access availability. In contrast, the financial and physical capital category included total land, livestock inventory, farming machinery, and secondary source of income. These variables were in either continuous or dummy (0, 1) form. Here, the decision-making power and innovativeness of women farmers related to agriculture are variables of interest that how these independent variables influence the implementation of different CSA combinations at the farm level.

The decision-making power and innovativeness of women farmers were enquired through different questions measured using five-point Likert scale questions. The women's empowerment in decision-making related to agriculture was measured using eleven different questions. The scores of women empowerment vary between eleven and fifty-five. Where a score of eleven shows the lowest empowerment and a score of fifty-five shows the highest empowerment in decision making for a women farmer. Similarly, the innovativeness of women farmers was measured using four questions in the study. The score of women farmers' innovativeness varies between four and twenty. A score of four for any woman farmer shows the lowest innovativeness, while a score of twenty shows maximum innovativeness. The empowerment and innovativeness scores were used as independent variables in the MVP model.

Moreover, we also applied a propensity score matching (PSM) to assess the effect of decisional empowerment and innovativeness on the adoption of CSA practices at women's farms. PSM technique compares the treated and control groups based on apparent characteristics [45]. Women farmers were divided into three groups based on their decisional empowerment (low, moderate, and highly empowered) and innovativeness (low, moderate, and highly innovative) scores separately by using K-mean cluster analysis. The treated group consisted of women farmers having higher decisional power, and higher innovativeness, while the control group consisted of women farmers with lower decisional power and lower innovativeness. The outcome variable used in PSM analysis was the individual composite indices of CSA practices (No. of adopted CSA strategies by a women farmer/total number of CSA practices) at the farm level. The common support assumption was also tested before analyzing the data through PSM. Researchers take most interest in estimates of the average treated effect on treated (ATT) and average treatment effect on untreated (ATU) [70]. Similarly, ATT is used to compare the expected CSA adoption outcome in the case of higher decisional empowerment with counterfactual CSA adoption outcomes concerning lower empowerment of the women farmers.

The actual CSA adoption outcome for women farmers with a higher decisional empowerment/innovativeness

$$E(Y_{ik}|I_i = k) = \beta_k X_{ik} \quad (3)$$

The counterfactual CSA outcome for women farmers, if they had lower decisional empowerment/innovativeness instead of higher decisional empowerment/innovativeness

$$E(Y_{ij}|I_i = k) = \beta_j X_{ik} \quad (4)$$

The average effect of decisional empowerment/innovativeness on the adoption of CSA practices conditional on higher decisional empowerment/innovativeness is defined as

$$\text{ATT} = E(Y_{ik}|I_i = k) - E(Y_{ij}|I_i = k) = X_{iK}(\beta_k - \beta_j) \quad (5)$$

3. Results and Discussion

3.1. Sample Background, Decisional Empowerment, and Innovativeness

Women in Pakistan face difficulty accessing educational facilities due to different socioeconomic barriers. The female literacy rate is very low in the country, which is also depicted in the findings presented in Table 2, as the average education level was only 6 years for women farmers. The average family size was more than 6 persons among study participants. Large family sizes are common in Pakistan, especially in rural areas of the country. The reason may be the joint family system of the country, particularly in rural areas where many families live together under one male or female headship. The findings corroborate with the national population census of the country that also reported an average family size in Pakistan of more than six members [61].

More than half of the women farmers participating in this study were living in the joint family system. This may be because of rural culture and traditions where people prefer living together under one roof. The findings related to women's farming experience indicated that women farmers were well experienced in farming activities. This may be because those women were involved in agriculture from childhood rather than attending school, confirming their lower education levels. The average land of women was less than 5 acres. The plausible explanation may be that more than two-thirds of the farmers in the country are subsistence or small farmers [3]. The average animal inventory was more than 4 animals among sampled women farmers. The reason may be that livestock and crop cultivation are integral. Majority of the farmers who work in crop cultivation also rear animals for an additional source of income. Almost two-thirds of the women farmers had a secondary source of income other than agriculture. The reason may be that women farmers work in fields while their spouses work in off-farm activities as daily wage workers in informal sectors. A large majority of the women farmers did not have any farming machinery such as tractors or tube wells. The reason may be that most women farmers were small farmers, and it might not be possible for them to purchase expensive farming machinery. Extension services were available only to one-fourth of the total women farmers.

Table 2. Sample background, decisional empowerment, and innovativeness indicators.

Variables	**Mean/Mode**
Human capital	
Age (years)	41.02 (10.76)
Education (years)	6.06 (3.18)
Family size (persons)	6.51 (2.17)
Family type (1 = joint, 0 = nuclear)	0.57 (0.41)
Farming experience (years)	8.51(2.33)
Financial and physical capital	
Total land (acres)	4.57 (1.96)
Livestock (number)	4.16 (2.10)
Farming machinery (1 = yes, 0 = no)	0.13 (0.28)
Secondary source of income (1 = yes, 0 = no)	0.62 (0.33)
Institutional factors	
Extension services (1 = yes, 0 = no)	0.25 (0.44)
Internet access (1 = yes, 0 = no)	0.21 (0.43)
Decisional Empowerment (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)	Mode
Sale/purchase of agricultural land	1
Rent in/rent out of agricultural land	2
Crop-related decisions	4
Farm machinery sale/purchase	1
Farm machinery usage	4
Agricultural inputs	4
Agricultural output/produce	3
Accessing agricultural credit	4
Use of agricultural credit	2
Allocation of time to different agricultural activities	4
Use of agricultural income	2
Decisional empowerment (mean)	3.39 (1.2)
Innovativeness (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)	
Use of new farming strategies	5
Get up-to-date information on farming strategies	4
Learn about new farming strategies from my fellow farmers	4
Often improve my farming strategies	3
Innovativeness (mean)	4.25 (1.3)

The values in parentheses indicate standard deviations.

The results related to women empowerment revealed that women farmers had lower power to decide about different farming activities. A large majority of the women farmers reported that they were not autonomous in deciding about the sale/purchase of farming land, renting agricultural land, and using farm machinery. Similarly, most women farmers also revealed that they did not have the decisional power to use agricultural income and credit independently. Women farmers face difficulty in decision-making related to farm activities and in accessing productive resources [14,70–72]. Conversely, most women farmers consider themselves empowered in decision-making related to agricultural input usage, accessing credit, time allocation to different activities, and crop cultivation decisions.

The results related to the innovativeness of women farmers in agriculture revealed that women farmers are highly innovative. Most women farmers showed that they liked to adopt new farm practices and were also keen to get the latest information on different farm practices.

3.2. Factors Influencing CSA Adoption at Women Farms

Agriculture in Pakistan is labor-intensive, and human capital plays an important role in adopting different CSA practices at the farm level in the country. Men and women farmers respond differently to climate change due to gender inequalities [73]. The age of the women farmers was negatively correlated with the combination of CSA strategies that need finance for adoption at the farm level (Table 3). Young farmers were more likely to implement those CSA strategies to adapt to climate change, which requires financial resources. The possible explanation may be that young farmers are generally risk-takers and ready to adopt new farm technologies relative to old farmers, characterized as risk-averse and resist new technologies. Moreover, old farmers also prefer to continue old farming systems without technology.

Table 3. Factors affecting adoption of different CSA combinations.

Explanatory Variables	Unskilled Labor		Skilled Labor		Financial Capital	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Human capital						
Age	0.03	0.02	−0.05	0.3	−0.47 ***	0.09
Education	0.08 ***	0.01	0.37 ***	0.04	0.32 ***	0.10
Family size	0.07 ***	0.02	−0.03	0.06	0.44	0.54
Farming experience	0.05	0.06	0.43 ***	0.05	0.65	0.38
Financial and physical capital						
Total land	−0.22	0.39	0.05 ***	0.02	0.47 ***	0.09
Livestock	0.32 ***	0.10	0.03	0.02	0.06 **	0.03
Farming machinery	0.44	0.54	1.08 ***	0.33	0.13 **	0.06
Secondary source	−1.46	1.59	0.32	0.30	0.65 ***	0.14
Institutional factors						
Extension services	0.28	0.32	1.06 ***	0.23	0.33 **	0.12
Internet access	−0.22	0.39	1.03 ***	0.34	0.47 ***	0.09
Decisional empowerment	0.06 **	0.03	0.09 ***	0.03	0.32 ***	0.10
Innovativeness	0.13 **	0.06	0.06 ***	0.01	0.44 **	0.19
Constant	−1.46	1.59	−1.50	1.43	0.65 ***	0.14
Wald χ^2	248.35					
Log Likelihood	−461.94					

*** and ** show significance levels at 1% and 5%, respectively.

Results also reveal that the education of women farmers positively influenced the adoption of all groups of CSA strategies at women's farms. The education of women farmers was positively influencing the adoption of all groups of CSA strategies at women's farms. Educated farmers were more likely to adopt practices from all CSA combinations at their farms. The probable explanation may be that educated women farmers are expected to be aware of climate change implications on their agriculture and ecosystem and the role of CSA in mitigating climate change better than lower educated women farmers, which prompts them to adopt more CSA practices to diminish the negative impact of climate change on their livelihood and environment. Family size was positively linked with implementing a CSA combination that required unskilled labor for adoption. The reason may be that family labor is the main source of the agricultural labor force for farming activities in the country, and it is still a livelihood for more than one-third of the population in the country. Most farmers take agriculture as their ancestors' occupation that requires no skill, training, or experience to perform the duties. Therefore, women farmers with large family sizes are more likely to implement strategies that do not involve any skill at their farms and require unskilled labor for adoption.

Similarly, it is observed that women farmers with greater farming experience were more likely to implement CSA strategies that require information and skill for adoption at the farm level. Knowledge and skill are basic requirements for adopting CSA practices included in skilled labor CSA combination, and farming experience itself is a skill during which a farmer learns about different farming activities, including CSA practices. Therefore, experienced women farmers may have the better skills and knowledge necessary to adopt CSA practices requiring skills for adoption at the farm level than women farmers with lower farming experience. The other reason may be that majority of the practices included in skilled labor CSA combination relate to conservation agriculture that maintains soil fertility. Therefore, women farmers with greater experience would be more aware of climate change's implications on soil fertility and eager to take more conservative practices to maintain soil fertility and agricultural productivity. The results related to age, education, family size, and farming experience corroborate with [3,38,61,69], who also reported similar findings as in our study.

Financial and physical capital is a prerequisite for adopting CSA at the farm level. Total agricultural land significantly and positively affected the adoption of CSA practices requiring skill and financial capital for adoption at the farm level. This may be because small women farmers lack in financial resources necessary to adopt these strategies. Moreover, small farmers are risk-averse and do not invest in risk-taking CSA farming practices. On the other hand, large farmers have more financial resources to invest in those CSA farming practices, which may yield improved agricultural productivity and environmental outcomes.

Livestock is an important component of agrarian activities in the study area. Study findings show that livestock inventory was positively associated with CSA practices that require unskilled labor and financial capital for adoption at the farm level. Women farmers with animal inventory were more likely to adopt CSA practices requiring unskilled labor and finance for adoption. The plausible justification may be that animals provide animal manure which is a CSA practice requiring unskilled labor for application. Therefore, women farmers with animal inventory can adopt animal manure CSA practice instead of mineral fertilizers saving money for other CSA practices requiring finance for adoption, such as the purchase of new sales, agroforestry, and bed raising at the time of cultivation of the crops. Secondly, animals are ready to cash and can be sold anytime to utilize the money in crop-related activities at the time of cultivation assisting women farmers in adopting CSA practices that require finance to adapt to climate change. The secondary source of women farmers was likely to enhance the probability of CSA practices that require financial capital for adoption at the farms. This may be because an additional source of income other than agriculture for women farmers can provide them with finance to purchase seeds and prepare beds at the time of cultivation, thus helping women farmers to adapt to climate change.

Institutional factors such as extension services play a key role in the adoption and diffusion of new farming practices and technologies, as also indicated by the result of our analysis. Women farmers having access to extension services were more likely to adopt CSA practices that require knowledge, skill, and finance for the adoption at the farms. The possible explanation may be that extension workers are the primary source of new information and guidance on farming activities and climate change for women farmers in the country. Therefore, access to extension services can increase women farmers' adaptation to climate change in the country. [49,74] describes that when women farmers have access to information, they are inclined to implement different CSA practices at their farms.

Women are crucial in ensuring food security and are an important part of global food systems and Pakistan [19]. More than 64% of women working labor force are employed in agriculture activities in the country [30]. The women perform all major tasks of agriculture, but they still lack decisional power in agriculture to decide about the different farming activities. The results related to the decisional empowerment of women in agriculture positively and significantly associated with all three combinations of CSA practices which indicate that empowering women in decision-making related agriculture can increase the adoption of CSA practices. Therefore, the world can benefit from empowering women in decision-making related to agriculture activities in the form of increased agricultural productivity, increased income, and lower GHG emissions from agriculture.

The innovativeness of women farmers was also found directly linked with the implementation of all combinations of CSA categories. Women farmers with greater innovativeness were more likely to implement CSA strategies at their farms. The reason may be that adopting CSA practices at women's farms requires divergence from traditional farming practices and systems. Therefore, the innovative behavior of women farmers can assist in adopting new CSA practices at the farm level.

3.3. Effect of Decisional Empowerment and Innovativeness on the Adoption of CSA Practices

Results presented in Table 4 revealed that women farmers with higher decisional power in agriculture adopted more CSA practices at their farms than women farmers with lower decisional power. Another important result is that all women farmers with a higher power in decision-making related to agriculture would have had lower adoption of CSA practices at their farms if they had not possessed higher decisional empowerment. Moreover, the average difference in CSA adoption between highly empowered women farmers and moderately empowered women farmers was smaller than the average difference between highly empowered women farmers and low empowered women farmers. Giving higher powers to women in agriculture as compared to low empowerment can increase the adoption of CSA practices at women's farms by 0.54. Similarly, giving moderate powers to women farmers compared to low powers can increase their adoption of CSA practices by 0.21. These findings also portray that women farmers with low decisional empowerment can increase their adaptation to climate change in a better way by having higher empowerment in decision-making in agricultural activities. Therefore, the world can benefit greatly from giving more power to women in agriculture in terms of increased adoption of CSA practices at the farm level, which can improve global food security and mitigate climate change.

Table 4. Average effect of decisional empowerment and innovativeness on the adoption of CSA practices.

Sample	**Decisional Empowerment Status**		**Average Difference**
Highly empowered	Highly empowered 0.69 (0.08)	Moderately empowered 0.47 (0.08)	0.23 ***
Highly empowered	Highly empowered 0.69 (0.08)	Low empowered 0.16 (0.07)	0.54 ***
Moderately empowered	Moderately empowered 0.43 (0.10)	Low empowered 0.22 (0.09)	0.21 ***
Sample	Innovativeness Status		
Highly Innovative	Highly innovative 0.78 (0.05)	Moderately innovative 0.49 (0.05)	0.29 ***
Highly Innovative	Highly innovative 0.78 (0.05)	Low innovative 0.46 (0.08)	0.32 ***
Moderately innovative	Moderately innovative 0.54 (0.06)	Low innovative 0.44 (0.06)	0.10 **

*** and ** show significance levels at 1% and 5%, respectively.

The findings related to women's innovativeness in agriculture depicted that more innovative women adopted more CSA practices at their farms than women farmers with lower innovativeness. Consistent with the above results, the average difference in CSA adoption between highly innovative women farmers and low innovative women farmers was greater than the average adoption difference between highly innovative women farmers and moderately innovative farmers. Highly innovative women farmers would have had 0.29 fewer CSA practices at their farms if they were moderately innovative instead of highly innovative women farmers. Similarly, moderately innovative women farmers would have had 0.10 lower CSA adoptions at their farm if they were low innovative instead of moderately innovative. Climate change adaptation, global food security, rural development, poverty reduction, and sustainability of natural resources depend on the innovative behavior of farmers [41,60].

4. Conclusions and Future Perspective

Women are part and parcel of agriculture and other food systems worldwide, especially in developing countries. Despite the social, economic, and environmental benefits of CSA, the adoption of CSA strategies remains low at the farm level in most developing countries. Women contribute more than half of the agricultural labor force globally, and their involvement and empowerment in decision-making related to agriculture can assist in increasing the CSA adoption at the farm level in developing countries. The results related to decisional empowerment of women farmers indicated that they lack power in important decisions related to agricultural activities such as sale/purchase farming land, rent in/rent out land, sale/purchase of farm machinery, use of agriculture credit, and spending farming income. On the other hand, women farmers were sufficiently empowered in decision-making related to crops, farm inputs, accessing credit, and farm machinery usage. Women farmers were innovative and keen to adopt new farming practices at their farms. The results of the MVP model revealed that women farmers' decisional empowerment and innovativeness were positively allied with the implementation of CSA strategies.

CSA is critical for sustainable farming as it improves the efficiency of farm resources, enhances resilience and farm productivity, decreases greenhouse gas emissions, and reduces food insecurity. Thus, CSA adoption presents opportunities for social, economic, and environmental benefits not only for the farmers but for the whole society. Therefore, women farmers should be empowered in decision-making to sovereign their control over important productive agricultural assets to fully utilize social, economic, and environmental benefits through enhanced CSA adoption on their farms. Empowering women in decision-making related to agriculture activities can not only enhance CSA adoption at the farm level but can also assist developing countries in fostering economic development in rural areas. Developing and prioritizing women's empowerment in national policies and recognizing the importance and role of women farmers in national planning agendas to combat climate vulnerabilities through farmer programs would further encourage CSA adoption in Pakistan. Thus, this study has important implications for achieving the United Nation's Sustainable Development Goals of gender equality (SDG5) and climate action (SDG13) in Pakistan and other developing countries.

This study could not take into account the nature of impact under joint decision-making by male and female counterparts of farm families as well as the role of the female farmer in other household chores and its impact both on housekeeping and/or farm productivity. This study thus provides an insight for future work to look into this aspect in detail. Moreover, the reaction of male members of the households needs to be documented regarding their perception of the work and decision-support level of female members.

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