



JOURNAL OF SOCIAL SCIENCES DEVELOPMENT



www.jssd.org.pk
editor@jssd.org.pk

GENDER AND STORAGE-BASED CLIMATE CHANGE ADAPTATION: DETERMINANTS OF HOME-MADE SEED USE AND CROP STORAGE AMONG SMALL LANDHOLDERS IN SOUTH PUNJAB, PAKISTAN

Anam Fida¹ & Muhammad Ramzan Sheikh²

¹PhD Scholar, School of Economics, Bahauddin Zakariya University, Multan, Pakistan,

Email: anamfida07@gmail.com

²Professor, School of Economics, Bahauddin Zakariya University, Multan, Pakistan,

Email: ramzansheikh@bzu.edu.pk

KEYWORDS	ABSTRACT
Climate change adaptation; Storage strategies; gender; Small landholders; Logit model; South Punjab; Pakistan	Climate change increasingly threatens the food and livelihood security of smallholder farmers in semi-arid regions such as South Punjab, Pakistan. Among the autonomous adaptation strategies available to farm households, storage-based adaptation, comprising the use of home-saved seed and crop storage offers a low-cost, time-tested buffer against production and market shocks, yet it remains one of the least studied adaptation pathways in the empirical literature, which has concentrated disproportionately on on-farm and diversification strategies. This study examines the gender-differentiated determinants of storage adaptation strategies among 1,152 small landholder farmers (974 male-headed and 178 female-headed households) drawn through proportionate sampling from the Multan, Bahawalpur, and DG Khan divisions of South Punjab. Using binomial logit regression, the study estimates the effects of eight categories of household and community-level factors, demographic characteristics, human capital, land-related variables, non-land assets and income, access to services, climate change exposure, food security, and planned adaptation support on the probability of using home-saved seed and engaging in crop storage. The results show that age, marital status, joint family structure, farming experience, land size and ownership, land quality, climate change exposure, food security, and planned adaptation support are positively associated with both storage strategies across most divisions for both genders, while access to services and, in most divisions, non-land assets and income exhibit divergent effects across the two sub-strategies. The findings inform gender-responsive policy for strengthening rural storage infrastructure and post-harvest resilience among small landholders.
ARTICLE HISTORY	
Date of Submission: 21-04-2026 Date of Acceptance: 25-05-2026 Date of Publication: 28-05-2026	
	
	2026 Journal of Social Sciences Development
Corresponding Author	Muhammad Ramzan Sheikh
Email:	ramzansheikh@bzu.edu.pk
DOI	https://doi.org/10.59075/jssd.v5i3.315
Volume/Issue	5(3), 2026, 162-181

Introduction

Climate change is one of the defining challenges facing global agriculture, food security, and rural livelihoods in the twenty-first century. The Intergovernmental Panel on Climate Change (IPCC) has documented rising global surface temperatures, more frequent heat extremes, and shifting precipitation patterns that are already disrupting food production systems, natural ecosystems, and water availability across much of the developing world (Hassan et al., 2005; Parry, 2007). Even under comparatively optimistic emissions-reduction scenarios, global temperatures are projected to continue rising for decades, meaning that adaptation rather than mitigation alone will remain central to safeguarding rural livelihoods (Parry, 2007). A community's or household's ability to adapt to these risks depends heavily on its adaptive capacity, which is shaped by socioeconomic characteristics such as financial resources, access to information and technology, institutional support, human capital, and social networks; households and communities with greater exposure and sensitivity to climate hazards, and lower adaptive capacity, face correspondingly higher vulnerability (Smit and Wandel, 2006).

For agriculture-dependent economies such as Pakistan, these risks are especially acute. Pakistan was ranked 8th among the countries most vulnerable to long-term climate risk in the Global Climate Risk Index 2021, a standing driven by a combination of high exposure to extreme weather events and comparatively constrained adaptive capacity (Eckstein et al., 2021). The country's agriculture, forestry, and water resources, the backbone of rural livelihoods, face intensifying pressure from recurrent droughts, more severe flooding, and increasingly erratic rainfall and temperature patterns. The 2010 floods alone affected roughly 20 million people, caused more than 1,600 deaths, and destroyed over 0.7 million hectares of standing crops, with recovery costs estimated between US\$8.74 and US\$10.85 billion (Khan and Salaman, 2012; Bukhari and Rizvi, 2017). In the arid and semi-arid agroecological zones of western and southern Pakistan, including South Punjab, rising temperatures threaten to accelerate glacial melt in headwater regions even as they intensify heat stress, drought, and soil degradation locally, altering growing seasons and increasing the risk of pest and disease pressure on crops (Khan et al., 2012).

South Punjab, comprising the Multan, Bahawalpur, and DG Khan divisions, sits squarely within this exposed landscape. Agriculture remains the primary source of rural livelihood in the province, sustained by river-fed irrigation from the Indus system, yet the region's farm households confront the same combination of rising temperatures, erratic monsoons, and recurring flood and drought cycles that afflict Pakistan more broadly. In the relative absence of comprehensive, reliably delivered government-led adaptation programs, small landholder households rely heavily on autonomous adaptation: self-directed adjustments to livelihood practices, made without external planning or advisory support, in direct response to observed or anticipated climatic change (Smit and Wandel, 2006).

Agrawal's influential typology, developed originally in the context of pastoral and agropastoral risk management, classifies these autonomous household-level responses into distinct categories

according to the risk-spreading mechanism each employs: on-farm adaptation (adjusting production practices), storage (spreading risk across time), diversification (spreading risk across income sources and assets), common pooling (spreading risk across households), mobility (spreading risk across space), and market exchange (spreading risk across households via trade) (Agrawal and Perrin, 2009). Of these, storage-based adaptation is arguably the most immediately accessible to resource-constrained smallholders. Unlike diversification or mobility, which typically require access to non-farm labor markets, or market exchange, which depends on functioning input and output markets, storage strategies, retaining seed from a household's own harvest and holding produce in reserve, require comparatively little beyond the accumulated knowledge, labor, and modest infrastructure a farming household already possesses. As such, storage functions as a low-cost buffer against total livelihood failure during a poor season, and improvements in storage technology and practice carry outsized potential to strengthen rural food security given the scale of post-harvest losses that continue to erode farm incomes throughout the developing world (Belay, 2017; Pizarro and Sainsbury, 2023).

Despite this accessibility, storage-based adaptation remains conspicuously understudied relative to on-farm practices and livelihood diversification in the empirical climate-adaptation literature. The overwhelming majority of published studies on smallholder adaptation, reviewed in Section 2, concentrate on the adoption of climate-resilient crop varieties, adjusted sowing dates, irrigation extension, and income diversification, while storage, common pooling, and mobility strategies receive comparatively little systematic, quantitative attention. Fewer studies still examine how the determinants of storage adaptation differ between male- and female-headed farm households, despite well-documented gender disparities in access to land, credit, extension services, and household decision-making authority that plausibly shape adaptation choices differently for men and women (Deressa et al., 2009; Atube et al., 2021). This gap is particularly consequential in the South Punjab context, where such disparities are pronounced and where no known prior study has examined storage adaptation determinants specifically.

This paper addresses that gap directly. Drawing on primary survey data from 1,152 small landholder households 974 male-headed and 178 female-headed across the Multan, Bahawalpur, and DG Khan divisions of South Punjab, it identifies the demographic, human capital, land-related, asset and income, service-access, climate-exposure, food-security, and planned-adaptation-related determinants of two storage-based autonomous adaptation strategies: the use of home-saved seed and crop storage. Binomial logit models are estimated separately for male- and female-headed households in each division and for South Punjab as a whole, allowing the determinants of storage adaptation to be compared not only across genders but also across the province's three constituent agroecological divisions. In doing so, the study makes three contributions: it provides the first regression-based, quantitative analysis of storage-adaptation determinants specific to South Punjab; it disaggregates the analysis by gender across all model specifications, addressing a persistent blind spot in the adaptation literature; and it examines the two storage sub-strategies, home-saved seed use and crop storage, separately, revealing that they do not always respond to the same determinants in the same direction.

The remainder of the paper proceeds as follows. Section 2 reviews the conceptual and empirical literature on storage adaptation and on each of the independent variable categories used in the analysis, and situates the study's contribution within the identified research gaps. Section 3 describes the study area, sampling procedure, variable construction, and econometric specification. Section 4 presents the descriptive and regression results and discusses each set of findings in relation to the existing literature. Section 5 concludes with a summary of findings and their policy implications.

Literature Review

Storage as a Climate Change Adaptation Strategy

Following Agrawal's classification of household risk-management strategies (Agrawal and Perrin, 2009), storage-based adaptation pools risk across time rather than across space, assets, or households. When paired with adequate infrastructure, low-perishability produce, and coordinated household practices, storage functions as a preventive buffer against the total failure of a household's livelihood base in a poor season (Belay, 2017). For individual farm households and rural communities alike, storage is central to managing recurrent food and water scarcity; improvements in storage technology and institutions carry substantial potential to strengthen rural livelihoods, given the scale of post-harvest losses that continue to erode farm incomes across the developing world (Pizarro and Sainsbury, 2023). In this study, storage adaptation comprises two sub-strategies: the use of home-saved seed, retaining seed from a household's own harvest for future planting, which supports local varietal resilience, biodiversity, and self-reliance in the face of shifting growing conditions, and crop storage, the practice of holding harvested output in reserve to guard against climate-related production shortfalls and to manage the timing of sales.

Empirical Literature on the Determinants of Adaptation Strategies

A substantial empirical literature examines the household- and community-level factors that shape smallholder farmers' adoption of climate change adaptation strategies.

Age, marital status, household structure, and dependency burden are consistently included in adaptation studies as proxies for accumulated experience, risk tolerance, and household labor capacity. In their widely cited study of the Nile Basin of Ethiopia, Deressa et al. (2009) found that the age, gender, and wealth of the household head were significant determinants of the choice of adaptation method, using a discrete choice framework applied to over a thousand farm households. Atube et al. (2021), analyzing determinants of adaptation among smallholder farmers in northern Uganda using binary logistic regression, similarly found household demographic characteristics, alongside access to extension and climate information, to be significant predictors of adaptation strategy adoption. Within the specific context of storage practices, household composition variables such as joint family structure and dependency burden have been linked to the pooling of labor and resources needed to coordinate seed-saving and storage activities (Atube et al., 2021; Batool et al., 2018; Tsusaka et al., 2021).

Farming experience and formal education are the two human-capital variables most frequently tested in the adaptation literature. Mabe et al. (2014), using binary logistic regression on survey data from northern Ghana, found that farming experience significantly and positively affected the choice of at least five distinct climate change adaptation strategies, alongside farm income, access to phones, and access to weather information. Education is also a robust predictor in the literature: Deressa et al. (2009) found education level to be among the strongest determinants of adaptation-method choice, while Ali and Erenstein (2017), studying adaptation practices among 950 farmers across Pakistan's major provinces, found that more educated farmers were significantly more likely to adopt climate risk-coping strategies, a finding they note is consistent with the broader literature linking education to technology and practice adoption.

Land size, ownership, and quality are near-universal predictors of adaptation capacity in the literature, reflecting both the physical space and the security of tenure needed to justify long-horizon adaptation investments. Ali and Erenstein (2017) report that landholding size is strongly associated with all major adaptation methods examined in their Pakistan-wide study, consistent with the broader literature on the positive relationship between farm size and technology adoption. Similar positive associations between land-related variables and adaptation or storage-specific practices are reported in studies of land quality, land fragmentation, and land ownership (Gebbru et al., 2020; Tesfahunegn et al., 2016; Kumar et al., 2023; Molla et al., 2023; Atube et al., 2021).

Household wealth, whether measured through non-land productive assets or income, shapes farmers' capacity to invest in both purchased inputs and storage infrastructure. Ali and Erenstein (2017) find that wealth indicators are closely associated with the adoption of climate-risk coping strategies in Pakistan, though they note that credit access itself showed no significant additional effect once wealth was controlled for, reflecting the relatively modest additional investment many adaptation strategies require. Other studies point to a more nuanced pattern in which asset and income effects diverge across specific sub-strategies, for instance, favoring purchased or certified inputs over home-saved alternatives while simultaneously supporting investment in storage infrastructure (Swai, 2017; Destaw and Fenta, 2021; Tesfahunegn et al., 2016).

Access to extension advice, credit, roads, and farmer organizations is one of the most consistently significant predictors of adaptation adoption in the literature. Ali and Erenstein (2017) report that extension services, access to paved roads, and association membership are all positively associated with the adaptation methods examined in their study, reflecting the role of information and resource access in empowering farm households to adopt climate-risk coping strategies. Deressa et al. (2009) similarly identify access to extension and credit as significant determinants of adaptation-method choice. At the same time, improved market and service access can also substitute for certain self-provisioning strategies, such as home-saved seed, where it enables farmers to purchase preferred inputs or sell produce promptly rather than storing it (Molla et al., 2023).

Farmers' direct experience of climate variability, temperature increases, altered rainfall, and

shifting monsoon timing, is widely found to reinforce adaptive behavior, as households that perceive greater climate risk are more likely to take precautionary action (Deressa et al., 2009; Abid et al., 2019). Within the storage literature specifically, greater climate exposure has been linked to increased reliance on traditional, low-cost buffering strategies such as seed-saving and crop storage (Batool et al., 2018; Elahi et al., 2022).

Food security status shapes both farmers' capacity and motivation to invest in adaptation. Farmers with greater food security have more resources and a longer planning horizon to invest in adaptation practices, while adaptation in turn reinforces food security by reducing production and post-harvest risk, a relationship several studies describe as mutually reinforcing (Mabe et al., 2014; Batool et al., 2018; Tsusaka et al., 2021).

A smaller body of literature examines how government-led, planned adaptation initiatives interact with farmers' autonomous adaptation choices. Where farmers have access to government adaptation information, training, and support, delivered through extension services, mobile phones, or agricultural department outreach, studies generally report a complementary, reinforcing relationship with autonomous adaptation rather than a crowding-out effect (Ali and Erenstein, 2017; Mabe et al., 2014). Sheikh et al (2023) applied binary logistic regression to examine gender disparities in on-farm climate change adaptation across South Punjab. The finding that food insecurity itself discourages adaptation uptake alongside persistent gender gaps in resource access carries clear and actionable implications for agricultural extension and social protection policy in the region.

Gender, Storage, and Climate Change Adaptation: Empirical Evidence

The empirical literature on climate change adaptation among smallholder farmers has expanded considerably over the past decade, but its coverage of adaptation strategies remains uneven. Most gender-focused studies emphasize on-farm strategies, climate-resilient varieties, crop shifting, adjusted sowing dates, while comparatively few examine mobility, diversification, or storage-based adaptation, and fewer still disaggregate these by the gender of the household head. Where storage practices are addressed, they tend to appear as a secondary or incidental finding within broader livelihood-vulnerability studies rather than as a primary object of analysis. Research on climate-vulnerable rural communities in Pakistan's mountainous and semi-arid regions, for instance, has linked deteriorating food storage capacity to broader patterns of resource degradation and social inequity in access to basic services, disproportionately burdening poorer households with limited adaptive capacity (Shahzad et al., 2019). Elsewhere, studies of seed-saving and post-harvest management point to farming experience, land quality, and household asset holdings as consistent correlates of storage-related practices, though the direction and strength of these relationships vary by context and are rarely tested separately for male- and female-headed households (Atube et al., 2021; Tsusaka et al., 2021; Molla et al., 2023).

Existing evidence on the gender dimension of adaptation more broadly suggests that male farmers in developing-country settings tend to report greater confidence and higher adoption

rates across adaptation strategies than female farmers, a pattern several studies attribute to persistent disparities in access to land, credit, information, and extension services (Deressa et al., 2009; Atube et al., 2021), while evidence from developed-country contexts is more mixed. This asymmetry, combined with the general neglect of storage-based strategies in the literature, motivates the present study's focus.

Three gaps in the literature motivate this study. First, quantitative, regression-based analysis of storage adaptation determinants is scarce; most available evidence is qualitative, descriptive, or nests storage as a minor category within a broader adaptation index. Second, few studies examine storage adaptation through a gender lens, and fewer still do so with a sample large enough to support separate estimation for male- and female-headed households across multiple sub-strategies and differentiated agroecological divisions. Third, no known study has examined the determinants of storage-based adaptation specifically within South Punjab, a province highly exposed to climate variability but under-represented in the adaptation literature relative to Pakistan's northern and coastal regions. This paper addresses all three gaps using primary survey data and a binomial logit framework applied separately to male- and female-headed households across three South Punjab divisions.

Materials and Methods

Study Area

South Punjab consists of three divisions, Multan, Bahawalpur, and DG Khan, of which each forms a part of the most populated province of Pakistan, Punjab. The province is located on the border of the monsoon climatic zone, and the summer temperature in the plains are the mid-30s of °C while the winter temperatures are about 10 degrees centigrade and the agriculture is the main source of rural means which is supported by river water irrigation. Multan Division (districts: Multan, Khanewal, Vehari, Lodhran) has a total population of around 12.27 million as per 2017 census. Bahawalpur Division (districts: Bahawalpur, Bahawalnagar, Rahim Yar Khan), with the arid Cholistan Desert, was home to about 11.45 million. DG Khan Division (districts: DG Khan, Layyah, Muzaffargarh, Rajanpur) sandy soils, periodic summer dust storms, temperature extremes from about 4 °C in winter to 42 °C in summer, was home to about 11.02 million as show in Figure 1. The three divisions are all highly vulnerable to perennial flooding, droughts, and increasing temperatures, and thus provide ideal contexts for examining spontaneous climate adaptation at the level of small landholders.

Data Source and Sampling Procedure

The primary data were collected through a closed ended questionnaire survey conducted in the three South Punjab divisions across a total of eleven districts. Sample size was calculated following the procedure given by Krejcie and Morgan (1970), which at 95% confidence level, is 384 for population of 1 million or more; this number was applied separately for each division and distributed proportionally among the component districts as per the area under cultivation is

given in Table 1. The resulting sample is 1,152 small landholder households, 384 from each division, out of which 974 are male-headed and 178 are female-headed.

Figure 1: Map of South Punjab



Table 1: Sample Size Determination by Division and District

Division	District	Sample Size (Krejcie & Morgan)	Sample (Actual)	Taken
Multan	Multan	91	120	
	Vehari	116	120	
	Khanewal	103	120	
	Lodhran	74	80	
Bahawalpur	Bahawalpur	95	110	
	Bahawalnagar	145	155	
	Rahim Yar Khan	144	154	
DG Khan	DG Khan	150	160	
	Layyah	95	105	
	Muzaffargarh	95	105	
	Rajanpur	44	54	
Total (South Punjab)		1,152	1,283	

Source: Sheikh et al (2023)

Storage Adaptation Strategies (Dependent Variables)

Two binary dependent variables capture storage based self-directed adaptation. Use of Home-Saved Seed (UHSS) is a binary variable that takes a value of 1 if the household is a seed saver (i.e. it collects and saves seed for replanting from its own harvest) and 0 if not; it represents a household's biological and genetic self-sufficiency under changing growing conditions. Crop Storage (CS) is a

dummy variable that equals 1 if the household stores harvested crop instead of selling or consuming all of the harvest at once, and 0 otherwise; it indicates a precautionary measure that helps to ensure the long-term availability of harvested output and also to mitigate weather-induced post-harvest losses.

Independent Variables

Eight categories of independent variables, drawn from the household survey and, where indicated, constructed through Principal Component Analysis (PCA), are used to model the two storage outcomes: (i) demographic characteristics, age, marital status, joint family system, and dependency burden (the ratio of non-earning to total household members); (ii) human capital, farming experience and years of schooling; (iii) land-related variables, land size, land ownership, and a land quality index (land fragmentation, soil quality, field slope, and land leveling); (iv) non-land assets and income, a non-land asset index (tractor, tube well, vehicle, and livestock ownership) and household income; (v) access to services, an index combining credit access, extension contact, road access, farmer-organization membership, and solar-powered tube well use; (vi) climate change exposure, an index of farmers' reported experience of climate change, temperature increases, altered rainfall, and shifting monsoon onset; (vii) food security, a nine-indicator index covering self-farmed food dependence, market exchange of crops for food, food shortage experience, and food-assistance reliance; and (viii) planned climate change adaptation, a seven-indicator index capturing farmers' exposure to, and engagement with, government adaptation programs and information channels. Table 2 summarizes variable definitions and measurement.

Table 2: Variables, Abbreviations, and Measurement

Category	Variable	Abbreviation	Measurement
Dependent Variables	Use of Home-Saved Seed (UHSS)	UHSS	1 = yes, 0 = no
Demographics	Crop Storage (CS)	CS	1 = yes, 0 = no
	Age	AGE	Continuous (years)
	Marital Status	MS	1 = married, 0 = unmarried
	Family System	FS	1 = joint family, 0 = otherwise
	Dependency Burden	DEPB	Continuous (non-earners / household members)
Human Capital	Farming Experience	FEXP	Continuous (years)
	Education	EDU	Continuous (years of schooling)
Land Related Variables	Land Size	LS	Continuous (hectares)
	Land Owner	LO	1 = yes, 0 = no
	Land Quality Index	LQI	Continuous (PCA index, 4 indicators)
Non-Land Assets & Income	Non-Land Assets Index	NLAI	Continuous (PCA index, 4 indicators)
	Income	INC	Continuous (PKR, monthly)
Access to Services	Access to Services Index	ASI	Continuous (PCA index, 5 indicators)
Climate Change	Climate Change Index	CCI	Continuous (PCA index, 4 indicators)
Food Security	Food Security Index	FSI	Continuous (PCA index, 9 indicators)

Planned Adaptation	Planned CC Adaptation	PCCAS	Continuous (PCA index, 7 indicators)
	Index		

Source: Sheikh et al (2023)

Econometric Model

Because both dependent variables are binary, the study employs the binomial logit model, which, unlike the linear probability model, constrains predicted probabilities to the [0,1] interval. The model specifies the probability of adopting a given storage strategy as a logistic function of the vector of independent variables X_i :

$$P(Y=1/X) = 1 / [1 + e^{-(\beta_0 + \beta'X_i)}] \quad (1)$$

which yields the estimable logit equation:

$$\ln[P/(1-P)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + \varepsilon \quad (2)$$

where P is the probability of adopting the strategy, X_i is the vector of demographic, human capital, land, asset, service-access, climate-exposure, food-security, and planned-adaptation variables, and β is the corresponding vector of coefficients. Because logit coefficients indicate only the direction and significance of an effect rather than its magnitude, marginal effects, the change in the probability of adoption associated with a one-unit change in a given regressor, holding other variables constant, are also reported, calculated as:

$$\partial P / \partial X_i = P(1-P)\beta_i \quad (3)$$

Both models are estimated separately for male- and female-headed households within each of the three divisions and for South Punjab as a whole.

Results and Discussion

Adoption Patterns of Storage Adaptation Strategies

Table 3 reports adoption rates for the two storage strategies by gender and division. Across South Punjab, 59.9% of surveyed households reported using home-saved seed, with a modest gender gap favoring male-headed households (61.0% versus 53.9% among female-headed households). Adoption was highest in Bahawalpur Division, where 69.4% of male-headed and 56.2% of female-headed households reported using home-saved seed. Crop storage was more widely adopted overall: 63.6% of South Punjab households stored harvested crops, with female-headed households reporting a marginally higher adoption rate (68.5%) than male-headed households (62.7%) at the provincial level, a pattern that reverses the gender gap observed for home-saved seed use. DG Khan Division recorded the highest crop-storage adoption among female-headed households (72.7%). These descriptive patterns suggest that while home-saved seed use follows a

more conventional gender gradient favoring male-headed households, crop storage adoption is comparatively more gender-balanced and, in several divisions, higher among female-headed households, a distinction explored further in the regression results below.

Table 3: Adoption of Storage Adaptation Strategies by Gender and Division

Strategy	Response	South Punjab	S. Punjab (M)	S. Punjab (F)	Multan (M)	Multan (F)	Bahawalpur (M)	Bahawalpur (F)	DG Khan (M)	DG Khan (F)
Use of Home-Saved Seed	Yes	690 (59.9)	594 (61.0)	96 (53.9)	198 (60.9)	31 (52.5)	222 (69.4)	36 (56.2)	203 (61.7)	29 (52.7)
	No	462 (40.1)	380 (39.0)	82 (46.1)	127 (39.1)	28 (47.5)	98 (30.6)	28 (43.8)	126 (38.3)	26 (47.3)
Crop Storage	Yes	733 (63.6)	611 (62.7)	122 (68.5)	203 (62.5)	38 (64.4)	200 (62.5)	44 (68.8)	208 (63.2)	40 (72.7)
	No	419 (36.4)	363 (37.3)	56 (31.5)	122 (37.5)	21 (35.6)	120 (37.5)	20 (31.2)	121 (36.8)	15 (27.3)

Note: Figures are frequency counts with column percentages in parentheses.

Determinants of Storage Adaptation Strategies

Tables 4 and 5 present binomial logit coefficients, significance levels, and marginal effects (in brackets) for the determinants of home-saved seed use and crop storage, respectively, estimated separately for male- and female-headed households in each division and for South Punjab as a whole.

Table 4: Determinants of Use of Home-Saved Seed (UHSS), Binomial Logit Results

Variables	MTN-M	MTN-F	BWP-M	BWP-F	DGK-M	DGK-F	SPB-M	SPB-F
Demographics								
Age	0.0237** [0.0056]	0.0184* [0.4893]	0.0421** [0.0101]	0.0560* [0.0138]	0.1835*** [0.0434]	0.3840*** [0.0957]	0.2389*** [0.0569]	0.3554*** [0.0883]
Marital Status	0.8657** [0.2061]	1.3907** [0.1118]	1.5079*** [0.3609]	2.4918** [0.6132]	0.9753** [0.2305]	1.1196*** [0.2791]	0.9917*** [0.2360]	1.3632** [0.3387]
Family System	0.0818* [0.0195]	0.9450** [0.2309]	0.3299*** [0.0790]	0.8106* [0.1995]	0.5393*** [0.0802]	0.4577*** [0.1141]	0.2680* [0.0638]	0.6170*** [0.1533]
Dependency Burden	0.7786* [0.1854]	0.3149*** [0.9001]	1.1139* [0.2666]	1.7243** [0.4243]	0.7262*** [0.1716]	0.0671*** [0.0167]	0.8907*** [0.2119]	0.3004*** [0.0746]
Human Capital								
Farming Experience	0.0234*** [0.0056]	0.0081** [0.8492]	0.0219 [0.0052]	0.0884** [0.0218]	0.0075*** [0.0018]	0.3191*** [0.0795]	0.8666*** [0.2062]	0.1349*** [0.0335]
Education	0.0782** [0.0186]	0.0655* [0.4885]	-0.0576* [-0.0138]	-0.0872* [-0.0215]	-0.0163 [-]	-0.1764 [0.0038]	~ [0.0440]	~ [0.5024*** -0.1195]
Land Related Variables								
Land Size	0.0817* [0.0195]	0.0350*** [0.8057]	0.0833*** [0.0199]	0.0518* [0.0128]	0.1234** [0.0292]	0.0539*** [0.0134]	0.1031*** [0.0245]	0.2422*** [0.0602]
Land Owner	0.2860 [0.0681]	0.7345** [0.5166]	0.0113*** [0.0027]	1.0043** [0.2471]	0.1959*** [0.0463]	0.2992*** [0.0746]	0.1428 [0.0340]	0.5965*** [0.1482]
Land Quality Index	0.9443* [0.2248]	3.1241 [0.1214]	1.0803*** [0.2586]	2.3197** [0.5709]	0.9323*** [0.2203]	1.8480*** [0.4606]	0.8844*** [0.2104]	2.1866** [0.5433]
Non-Land Assets and Income								
Non-Land Assets Index	0.0928*	1.7063***	-0.0850***	-4.1879***	-0.1129***	-1.6744	-	-1.9571**

	[0.0221]	[0.3009]	[-0.0203]	[-1.0306]	[-0.0267]	[-0.4174]	0.9880***	[-0.4862]
Income	-0.1363*** [-0.0324]	-0.1485** [-0.6376]	-0.0773*** [-0.0185]	-0.0902** [-0.0222]	~ 0.0883*** [-0.0209]	~ 0.0807*** [-0.0201]	0.2351] -0.1033** [-0.0246]	-0.1182*** [-0.0294]
Access to Services								
Access to Services Index	0.2244** [0.0534]	-1.3727** [-0.4434]	-0.5546*** [-0.1328]	-2.9949* [-0.7370]	~ 0.0483*** [-0.0114]	~ 1.3997*** [-0.3489]	~ 0.9676*** [-0.2302]	-1.7907* [-0.4449]
Climate Change								
Climate Change Index	0.5353* [0.1274]	0.7562 [0.5379]	0.8145* [0.1950]	1.4168 [0.3487]	0.3587*** [0.0848]	0.3618*** [0.0902]	0.3295* [0.0784]	0.7713*** [0.1916]
Food Security								
Food Security Index	2.0530*** [0.4888]	1.7614* [0.3767]	2.1403*** [0.5123]	1.0318** [0.2539]	1.1116*** [0.2627]	1.0795*** [0.2691]	1.7614*** [0.4191]	0.1078*** [0.0268]
Planned Climate Change Adaptation Strategies								
Planned Climate Change Adaptation Index	2.4094*** [0.5736]	0.7667*** [0.1912]	0.0952*** [0.0227]	2.4810*** [0.6104]	1.8644*** [0.4406]	2.5208*** [0.6283]	1.8524*** [0.4407]	0.5557*** [0.1388]

Note: Cell values are logit coefficients with marginal effects in brackets. *** p<0.01, ** p<0.05, * p<0.10.

MTN = Multan, BWP = Bahawalpur, DGK = DG Khan, SPB = South Punjab

M = male-headed, F = female-headed households.

Table 5: Determinants of Crop Storage (CS), Binomial Logit Results

Variables	MTN-M	MTN-F	BWP-M	BWP-F	DGK-M	DGK-F	SPB-M	SPB-F
Demographics								
Age	0.0103*** [0.0024]	0.0095** [0.0022]	0.0132** [0.0031]	0.2865*** [0.0616]	0.9634*** [0.2240]	0.0200*** [0.0040]	0.9158*** [0.2141]	0.1262*** [0.0272]
Marital Status	0.0589*** [0.0138]	0.3414*** [0.0783]	0.0898* [0.0210]	1.2945 [0.2781]	0.6603*** [0.1535]	0.5905*** [0.1171]	0.2612*** [0.0611]	0.4365*** [0.0941]
Family System	0.2479 [0.0581]	0.0577*** [0.0132]	0.1629*** [0.0382]	1.0824*** [0.2325]	0.2919*** [0.0679]	1.0361*** [0.2055]	0.1624*** [0.0380]	0.2601*** [0.0561]
Dependency Burden	~ 0.5409*** [-0.1260]	3.9746*** [0.9112]	-1.1450* [-0.2680]	6.8308*** [1.4675]	~ 0.8682*** [-0.2019]	11.9490*** [2.3701]	~ 0.8194*** [-0.1916]	4.2078*** [0.9073]
Human Capital								
Farming Experience	0.0068*** [0.0016]	0.0258*** [0.0059]	0.0023*** [0.0005]	0.1683* [0.0362]	0.0302* [0.0070]	0.0756*** [0.0150]	0.9536*** [0.2229]	0.1247*** [0.0269]
Education	0.0151*** [0.0035]	0.0221*** [0.0051]	0.0040*** [0.0009]	0.4308* [0.0926]	0.0382 [0.0089]	0.0403*** [0.0080]	0.1497*** [0.0350]	0.2566*** [0.0553]
Land Related Variables								
Land Size	0.1002*** [0.0235]	0.0205*** [0.0047]	0.0958* [0.0225]	0.0959*** [0.0206]	0.0265*** [0.0062]	0.1962*** [0.0389]	0.6217** [0.1453]	0.4419** [0.0953]
Land Owner	0.6393** [0.1499]	0.9297* [0.2131]	0.2015*** [0.0472]	0.1994* [0.0428]	0.5591* [0.1300]	0.5807*** [0.1152]	0.4476*** [0.1046]	0.1950*** [0.0420]
Land Quality Index	0.6992* [0.1639]	1.1956** [0.2741]	0.6148*** [0.1441]	0.7944* [0.1707]	0.3025*** [0.0703]	1.9557*** [0.3879]	0.2935*** [0.0686]	0.5472*** [0.1180]
Non-Land Assets and Income								
Non-Land Assets Index	0.5980*** [0.1402]	0.0520* [0.0119]	0.4126*** [0.0967]	3.1903* [0.6854]	2.2162*** [0.5153]	2.2387*** [0.4440]	0.9913*** [0.2318]	0.9202 [0.1984]
Income	0.0736*** [0.0173]	0.1118*** [0.0256]	0.0218*** [0.0051]	0.2315* [0.0497]	0.1125*** [0.0262]	0.1035*** [0.0205]	0.8663* [0.2026]	0.0392*** [0.0084]
Access to Services								

Access to Services Index	1.0638* [0.2494]	-1.4856** [-0.3400]	~ [0.8292*** [-0.1940]	-0.9895* [-0.2120]	~ [0.5759*** [-0.1330]	-9.9167** [-1.9660]	~ [0.8083** [-0.1890]	~ [2.3242** [-0.5010]
Climate Change								
Climate Change Index	0.7054** [0.1654]	0.1680*** [0.0385]	0.1769 [0.0415]	0.3984* [0.0856]	0.1903*** [0.0442]	3.8952** [0.7726]	0.6673*** [0.1560]	0.7119*** [0.1535]
Food Security								
Food Security Index	0.5299** [0.1242]	0.8559 [0.1962]	1.3044* [0.3057]	0.5812* [0.1249]	0.6897*** [0.1604]	6.9613* [1.3807]	0.6455*** [0.1509]	1.1458*** [0.2471]
Planned Climate Change Adaptation Strategies								
Planned Climate Change Adaptation Index	0.3543*** [0.0831]	1.5437*** [0.3539]	2.4319*** [0.5699]	1.5609*** [0.3553]	1.1891*** [0.2763]	0.0273*** [0.0054]	1.9582*** [0.4578]	1.5797*** [0.3406]

Note: Cell values are logit coefficients with marginal effects in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

MTN = Multan, BWP = Bahawalpur, DGK = DG Khan, SPB = South Punjab

M = male-headed, F = female-headed households.

Discussion

This section interprets the regression results reported in Tables 4 and 5.

Demographic Factors

Age

Age is positively associated with both home-saved seed use and crop storage among male and female farmers across all three divisions and South Punjab as a whole (Tables 4–5). Older farmers have typically accumulated seed-saving knowledge and post-harvest storage practices over years of farming, often inherited from earlier generations, and tend to place greater value on preserving traditional varieties and household food security (Tsusaka et al., 2021; Shah et al., 2021). This result is consistent with Deressa et al. (2009), who found the age of the household head to be a significant determinant of adaptation-method choice in the Nile Basin of Ethiopia, and with the broader pattern in the adaptation literature in which accumulated farming experience associated with age reinforces reliance on traditional risk-management practices.

Marital Status

Married male and female farmers are significantly more likely than unmarried farmers to use home-saved seed and to store crops, across all divisions. Marriage brings a division of labor and shared decision-making within the household that supports the coordination seed selection, harvesting, and storage require, along with a longer planning horizon that favors investment in storage infrastructure (Atube et al., 2021; Elahi et al., 2022). This finding is consistent with Atube et al. (2021), who identified household demographic composition, including marital status, as a significant predictor of adaptation strategy adoption among smallholder farmers in northern Uganda.

Family System

Households practicing a joint family system are more likely to adopt both storage strategies. The larger resource and labor pool available in joint households, spanning multiple generations, supports both the intergenerational transmission of seed-saving traditions and the collective investment and maintenance of storage facilities, while also providing a buffer against storage-related risks such as pest damage or spoilage (Atube et al., 2021; Batool et al., 2018; Tsusaka et al., 2021; Molla et al., 2023). This result aligns with evidence that larger, multi-generational households are better able to pool labor and knowledge in support of adaptation practices (Atube et al., 2021).

Dependency Burden

This variable shows a more differentiated pattern. Among male farmers, a higher dependency burden is positively associated with home-saved seed use but negatively associated with crop storage, consistent with resource-constrained households prioritizing the low-cost seed-saving option while lacking the time and capital for storage infrastructure. Among female farmers, dependency burden is positively linked to both strategies, suggesting that women in high-dependency households may treat seed-saving and crop storage as complementary means of securing household food supply under resource constraint. This offsetting pattern echoes the broader finding that household demographic composition shapes adaptation strategy choice differently depending on the resource intensity of the strategy in question (Deressa et al., 2009).

Human Capital

Farming Experience

Farming experience is positively and significantly associated with both home-saved seed use and crop storage among male and female farmers across all divisions. Experienced farmers have a deeper, accumulated understanding of local growing conditions, seed viability, and storage conditions that allows them to save seed and store produce more effectively (Atube et al., 2021). This result is consistent with Mabe et al. (2014), who found that farming experience significantly and positively affected the choice of at least five distinct climate change adaptation strategies among farmers in northern Ghana.

Education

Education displays a divergent effect on the two strategies. In Bahawalpur, DG Khan and Southern Punjab in general, education was positively related to non-use of saved seed, most plausibly due to educated farmers' better access to, and confidence in, certified commercial seed; but also, positively related to crop storage that is consistent with greater knowledge of post-harvest management (Batool et al., 2018; Hirpha et al., 2020). In Multan Division, by contrast, education is positively associated with both outcomes, suggesting that formal education there is

complementary to, rather than a substitute for, traditional seed-saving knowledge. The positive relationship between education and crop storage is consistent with Ali and Erenstein (2017), who found that more educated farmers in Pakistan were significantly more likely to adopt climate risk-coping strategies, and with Deressa et al. (2009), who identified education as among the strongest determinants of adaptation-method choice.

Land-Related Factors

Land size, land ownership and land quality are each positively and significantly associated with both home-saved seed use and crop storage across all divisions and genders. Larger, higher-quality, and securely owned landholdings provide farmers with the physical space, crop diversity, and tenure security needed to save seed and to justify investment in storage infrastructure such as warehouses, silos, and storage bins, while also generating the larger harvests that make storage economically worthwhile (Kumar et al., 2023; Tsusaka et al., 2021; Molla et al., 2023; Gebru et al., 2020; Tesfahunegn et al., 2016; Atube et al., 2021). This finding is consistent with Ali and Erenstein (2017), who report that landholding size is strongly associated with all major adaptation methods examined in their nationwide Pakistan study, in line with the wider literature linking farm size to adaptation-technology adoption.

Non-Land Assets and Income

The non-land asset index shows opposite effects on the two outcomes in Bahawalpur, DG Khan, and South Punjab: it is negatively associated with home-saved seed use but positively associated with crop storage, for both male and female farmers. Households with greater mechanization and asset holdings appear to substitute purchased, certified seed for home-saved seed, while using their assets, tractors, tube wells, vehicles, livestock, to build, maintain, and transport produce to storage facilities (Swai, 2017; Destaw and Fenta, 2021; Batool et al., 2018; Tsusaka et al., 2021). In Multan Division, however, the non-land asset index is positively associated with both outcomes, suggesting that greater financial stability there supports traditional seed-saving alongside storage investment. Income follows a similar pattern across all divisions: it is negatively associated with home-saved seed use, as higher-income farmers substitute toward commercially bred seed, but positively associated with crop storage, reflecting greater capacity to invest in storage facilities and to time crop sales strategically (Tefahunegn et al., 2016; Molla et al., 2023). The general association between household wealth and adaptation-strategy adoption is consistent with Ali and Erenstein (2017), who find wealth indicators closely associated with the adoption of climate risk-coping strategies in Pakistan.

Access to Services

Access to services is negatively associated with both home-saved seed use and crop storage across all divisions and genders, with the exception of male farmers in Multan Division, where the relationship is positive. Farmers with greater access to credit, extension advice, roads, and farmer-organization membership appear more likely to substitute purchased seed for home-saved seed

and to sell produce promptly, via improved market access, rather than storing it (Tsusaka et al., 2021; Molla et al., 2023). This negative relationship for home-saved seed contrasts with the generally positive role that access to services plays for adaptation strategies overall in the literature: Ali and Erenstein (2017) find that extension services, paved-road access, and farmer-association membership are positively associated with the adaptation methods they examine in Pakistan, and Deressa et al. (2009) similarly identify extension and credit access as significant determinants of adaptation choice, suggesting that, for storage strategies specifically, improved service access operates as a substitute for self-provisioning rather than a complement, except in Multan Division, where access to services appears instead to function as a complement to both storage practices among male farmers, plausibly reflecting extension programs and seed banks that actively support seed-saving and storage skills in that division.

Climate Change Exposure

Farmers' reported exposure to climate change, encompassing experienced temperature increases, altered rainfall, and shifting monsoon timing, is positively and significantly associated with both home-saved seed use and crop storage across all divisions and genders. Greater climate exposure appears to reinforce reliance on traditional, low-cost adaptation practices as farmers seek to safeguard seed stocks and harvested output against increasingly unpredictable conditions (Batool et al., 2018; Abid et al., 2019; Elahi et al., 2022). This result is consistent with Deressa et al. (2009), who found that farmers' perception of and exposure to climate change was a significant driver of adaptation-method choice in Ethiopia.

Food Security

The food security index is positively associated with both storage strategies across all divisions and genders. Food-secure households appear better positioned, in terms of both confidence and available resources, to invest time and capital in traditional seed-saving and storage practices, which in turn reinforce food stability by preserving surplus produce and reducing exposure to lean-period shortages. This bidirectional, mutually reinforcing relationship between food security and adaptation is consistent with Mabe et al. (2014) and Tsusaka et al. (2021), both of whom report positive associations between household food security status and adaptation-strategy adoption.

Planned Climate Change Adaptation Strategies

The planned adaptation index, capturing farmers' exposure to government-disseminated adaptation information and support, is positively associated with both home-saved seed use and crop storage across all divisions and genders. This finding suggests that government-led adaptation initiatives complement, rather than crowd out, farmers' autonomous storage-based strategies, reinforcing farmers' capacity to safeguard seed stocks and harvests as part of a broader resilience-building effort. This complementarity is consistent with Ali and Erenstein (2017) and Deressa et al. (2009), both of whom find that institutional support, delivered through extension services, information campaigns, and access to credit, positively reinforces farmers' own

adaptation efforts rather than substituting for them.

Conclusion and Policy Implications

This study examined the gender-differentiated determinants of storage-based climate change adaptation, home-saved seed use and crop storage, among 1,152 small landholder households in the Multan, Bahawalpur, and DG Khan divisions of South Punjab, Pakistan. Using binomial logit models estimated separately for male- and female-headed households, the results show that age, marital status, joint family system, farming experience, land size, land ownership, land quality, climate change exposure, food security, and exposure to planned government adaptation programs are consistently positive and significant determinants of both storage strategies across genders and divisions. Non-land assets, income, and access to services, by contrast, show a consistent divergence: each is generally negatively associated with home-saved seed use but positively associated with crop storage, with the notable exception of Multan Division, where several of these relationships turn positive for both outcomes. Dependency burden similarly shows offsetting effects on the two strategies among male farmers.

These findings carry several policy implications. First, the consistent, cross-cutting importance of land quality, land ownership, and food security for both storage strategies points to synergies between land-tenure security programs, land-improvement initiatives, and food-security safety nets on the one hand, and storage-based climate resilience on the other; strengthening any of these is likely to reinforce farmers' capacity to save seed and store crops. Second, the divergence between home-saved seed use and crop storage in their relationship to income, non-land assets, and access to services suggests that policy should not treat storage adaptation as a single undifferentiated category: interventions that improve farmers' access to credit, extension, and markets may inadvertently reduce reliance on home-saved seed even as they support crop storage, and program design should account for this trade-off, for example, by pairing seed-bank or seed-diversity programs with market-access initiatives rather than treating the latter as a substitute for the former. Third, the positive association between planned-adaptation exposure and both storage strategies indicates that government information and training programs are complementary to farmers' autonomous adaptation efforts; expanding the reach of these programs, particularly via mobile phone, radio, and agricultural-department outreach, is likely to reinforce rather than displace farmers' own storage-based coping strategies. Finally, given the largely consistent direction of effects between male- and female-headed households, gender-responsive programming in this domain should focus less on differentiated strategy design and more on closing the underlying resource gaps, in land, assets, income, and services, that continue to leave female-headed households at lower average levels of storage-strategy adoption despite facing similar directional incentives.

As with any single-region study, these findings are specific to the agroecological and socio-economic conditions of South Punjab and should be interpreted with appropriate caution when generalizing to other contexts. Future research could usefully extend this analysis to a wider range

of storage practices, examine the interaction between storage adaptation and the other categories of autonomous adaptation identified by Agrawal's typology, and track how storage-strategy adoption evolves as government planned-adaptation programs expand.

References

- Agrawal, A., & Perrin, N. (2009). Climate adaptation, local institutions and rural livelihoods. In W. N. Adger, I. Lorenzoni, & K. L. O'Brien (Eds.), *Adapting to Climate Change: Thresholds, Values, Governance* (pp. 350–367). Cambridge University Press.
- Ali, A., & Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*, 16, 183–194. <https://doi.org/10.1016/j.crm.2016.12.001>
- Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agriculture & Food Security*, 10, Article 6. <https://doi.org/10.1186/s40066-020-00279-1>
- Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, 19(2), 248–255. <https://doi.org/10.1016/j.gloenvcha.2009.01.002>
- Eckstein, D., Künzel, V., & Schäfer, L. (2021). Global Climate Risk Index 2021: Who suffers most from extreme weather events? Weather-related loss events in 2019 and 2000–2019. Germanwatch.
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(3), 607–610.
- Mabe, F. N., Sienso, G., & Donkoh, S. A. (2014). Determinants of choice of climate change adaptation strategies in northern Ghana. *Research in Applied Economics*, 6(4), 75–94. <https://doi.org/10.5296/rae.v6i4.6121>
- Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16(3), 282–292. <https://doi.org/10.1016/j.gloenvcha.2006.03.008>
- Abid, M., Scheffran, J., Schneider, U. A., & Elahi, E. (2019). Farmer perceptions of climate change, observed trends and adaptation of agriculture in Pakistan. *Environmental Management*, 63, 110–123. <https://doi.org/10.1007/s00267-018-1113-7>
- Batool, H., Ali, W., Manzoor, R., & Mahmood, N. (2018). Women's perception of climate change and coping strategies in Pakistan: An empirical evidence. *Earth Systems and Environment*, 2, 609–619. <https://doi.org/10.1007/s41748-018-0073-7>
- Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture & Food Security*, 6, 24. <https://doi.org/10.1186/s40066-017-0100-1>
- Bukhari, S. I. A., & Rizvi, S. S. H. (2017). Impact of 2010 floods on Pakistan's agriculture. *Journal of*

- Environmental & Analytical Toxicology*, 7(1), 1–4. <https://doi.org/10.4172/2161-0525.1000424> (ResearchGate)
- Destaw, F., & Fenta, M. M. (2021). Climate change adaptation strategies and their predictors amongst rural farmers in Ambassel district, Northern Ethiopia. *Jamba: Journal of Disaster Risk Studies*, 13(1), 974. <https://doi.org/10.4102/jamba.v13i1.974>
- Elahi, E., Khalid, Z., Tauni, M. Z., Zhang, H., & Lirong, X. (2022). Extreme weather events risk to crop-production and the adaptation of innovative management strategies to mitigate the risk: A retrospective survey of rural Punjab, Pakistan. *Technovation*, 117, 102255. <https://doi.org/10.1016/j.technovation.2021.102255>
- Khan, F. A., & Salman, A. (2012). A simple human vulnerability index to climate change hazards for Pakistan. *International Journal of Disaster Risk Science*, 3(3), 163–176.
- Gebru, G. W., Ichoku, H. E., & Phil-Eze, P. O. (2020). Determinants of smallholder farmers' adoption of adaptation strategies to climate change in Eastern Tigray National Regional State of Ethiopia. *Heliyon*, 6(7), e04356. <https://doi.org/10.1016/j.heliyon.2020.e04356>
- Hirpha, H. H., Mpandeli, S., & Bantider, A. (2020). Determinants of adaptation strategies to climate change among the smallholder farmers in Adama District, Ethiopia. *International Journal of Climate Change Strategies and Management*, 12(4), 463–476. <https://doi.org/10.1108/IJCCSM-01-2019-0002>
- Khan, S., Hasan, M. U., & Khan, M. A. (2012). People perception about climate change and adaptation in the arid region of Pakistan. *Peshawar: Institute of Geography, Urban and Regional Planning University of Peshawar KPK, Pakistan*.
- Kumar, K. N., Reddy, M. J., Reddy, K. V., Paramesha, V., Balasubramanian, M., Kumar, T. K., et al. (2023). Determinants of climate change adaptation strategies in South India: Empirical evidence. *Frontiers in Sustainable Food Systems*, 7, 1010527. <https://doi.org/10.3389/fsufs.2023.1010527>
- Molla, E., Melka, Y., & Desta, G. (2023). Determinants of farmers' adaptation strategies to climate change impacts in northwestern Ethiopia. *Heliyon*, 9(8), e18514. <https://doi.org/10.1016/j.heliyon.2023.e18514>
- Pizarro, J., & Sainsbury, B. (2023). Climate adaptation in the spent fuel storage and disposal facilities: A literature review. *Annals of Nuclear Energy*, 192, 109954. <https://doi.org/10.1016/j.anucene.2023.109954>
- Shah, A., Nazari, M., Antar, M., Msimbira, L. A., Naamala, J., Lyu, D., ... & Smith, D. L. (2021). PGPR in agriculture: A sustainable approach to increasing climate change resilience. *Frontiers in Sustainable Food Systems*, 5, 667546.
- Shahzad, L., Tahir, A., Sharif, F., Khan, W. U. D., Farooq, M. A., Abbas, A., & Saqib, Z. A. (2019). Vulnerability, well-being, and livelihood adaptation under changing environmental conditions: A case from mountainous region of Pakistan. *Environmental Science and Pollution Research*, 26, 26748–26764. <https://doi.org/10.1007/s11356-019-05880-x>
- Sheikh, M. R., Fida, A., & Sultan, S. (2023). Exploring Gender Dynamics in On-Farm Climate Change Adaptation Strategies and Food Security among Smallholder Farmers in South Punjab, Pakistan. *IUB Journal of Social Sciences*, 5(2), 398–418.

- Swai, O. W. (2017). Determinants of adaptation to climate change: A gendered analysis from Bahi and Kondoa Districts, Dodoma Region, Tanzania. *Journal of Sustainable Development*, 10(2), 155–169. <https://doi.org/10.5539/jsd.v10n2p155>
- Tesfahunegn, G. B., Mekonen, K., & Tekle, A. (2016). Farmers' perception on causes, indicators and determinants of climate change in northern Ethiopia: Implication for developing adaptation strategies. *Applied Geography*, 73, 1–12. <https://doi.org/10.1016/j.apgeog.2016.05.009>
- Tsusaka, T. W., et al. (2021). *Do rice varieties matter? Climate change adaptation and livelihood diversification among rural smallholder households in the Mekong Delta region of Vietnam*. <https://doi.org/10.1007/s11027-021-09978-x>