

Gender and Livelihood Diversification as Climate Change Adaptation: Determinants of Non-Farm Engagement and Multiple Income-Generating Activities among Small Landholders in South Punjab, Pakistan

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Abstract

Small landholders in South Punjab, Pakistan, face rising temperatures, erratic monsoons and recurring floods and droughts, and many respond by spreading their livelihoods beyond a single crop or a single source of income. This study examines the gender-differentiated determinants of two diversification-based autonomous adaptation strategies: engagement in non-farm activities and participation in multiple income-generating activities. Primary survey data were collected from 1,152 small landholder households (974 male-headed and 178 female-headed) in the Multan, Bahawalpur and DG Khan divisions using proportionate sampling. Binomial logit models, with marginal effects, were estimated separately for male- and female-headed households in each division and for South Punjab as a whole. At the provincial level, 56.7% of male-headed and 47.2% of female-headed households engaged in non-farm work, while the share pursuing multiple income-generating activities was almost identical across genders (59.3% and 59.6%). Marital status, joint family structure, dependency burden, education, land size, land ownership, land quality, income, access to services, climate change exposure, food security and planned adaptation support were positively associated with both strategies in most specifications. Age and farming experience were negatively associated with diversification outside Multan Division. The non-land asset index was the clearest point of gender divergence: it raised the probability of both strategies among male-headed households but lowered the probability of non-farm engagement among female-headed households in every division, while still raising their participation in multiple income-generating activities. The marginal effects of access to services and education on non-farm engagement were also several times larger for women than for men. The findings suggest that female-headed households diversify mainly through farm-linked and home-based income sources, and that service access and education are the main levers for widening their options outside agriculture.

Keywords: climate change adaptation, livelihood diversification, non-farm employment, gender, small landholders, logit model, South Punjab, Pakistan

1. Introduction

Climate change is now one of the main threats to agriculture and rural livelihoods in developing countries. Rising temperatures, more frequent heat extremes and shifting rainfall patterns are already affecting crop yields, water availability and the timing of farm operations, and these effects are expected to continue for decades even if emissions fall. Adaptation therefore remains central to protecting rural incomes. A household's ability to adapt depends on its adaptive capacity, which is shaped by financial resources, access to information and technology, institutional support, human capital and social networks. Households with greater exposure and sensitivity to climate hazards and lower adaptive capacity are correspondingly more vulnerable (Smit and Wandel, 2006).

Pakistan is among the countries most exposed to these risks. It was ranked 8th in the long-term Global Climate Risk Index 2021 on the basis of losses from extreme weather events between 2000 and 2019 (Eckstein et al., 2021). The 2010 floods alone affected about 20 million people, killed more than 1,700, damaged or destroyed nearly 1.1 million homes and caused an estimated US\$9.7 billion in damage, with heavy losses of crops, livestock and seed stocks (Kirsch et al., 2012). Agriculture remains the main source of rural employment, and a large share of farm households operate small holdings with limited savings, which leaves them with few buffers when a season fails (Khan and Salman, 2012).

South Punjab, made up of the Multan, Bahawalpur and DG Khan divisions, is a clear example. Its farms depend on canal and tube-well irrigation drawn from the Indus system, and its households face high summer temperatures, erratic monsoon onset, and recurring flood and drought cycles. DG Khan in particular has been identified as one of the most climate-vulnerable districts in Pakistan's semi-arid zone, largely because of flood exposure and limited irrigation access (Qaisrani et al., 2018). Government adaptation programmes reach only part of this population, so most small landholders rely on autonomous adaptation: adjustments they make themselves, without external planning, in response to the changes they observe.

Agrawal and Perrin (2009) classify these household responses by the way each spreads risk. On-farm adaptation adjusts production practices; storage spreads risk over time; diversification spreads it across assets and income sources; common pooling spreads it across households; and mobility spreads it across space. Diversification has a long history in the rural livelihoods literature, where it is understood as the process by which households build a portfolio of activities so that a loss in one does not wipe out the whole livelihood (Ellis, 1998; Barrett et al., 2001). When crop income becomes less predictable, earnings from wage labour, trade, services, livestock or small enterprises can smooth consumption and pay for inputs in the next season. In Pakistan's flood-affected areas, diversification into on-farm and off-farm activities has been shown to be one of the main ways farm households manage catastrophic risk (Shah et al., 2021).

Diversification is not equally open to everyone. Taking up non-farm work usually requires education, skills, time free from farm and household duties, transport, and contacts in local labour markets. Many of these are distributed unequally between men and women. In rural Pakistan, social norms limit women's mobility and their access to credit, extension services and paid employment outside the home, and female-headed households often hold less land and fewer productive assets. Evidence from rural Tanzania shows that access to diversification

strategies depends on the intersection of gender and marital status rather than on gender alone (Van Aelst and Holvoet, 2016). It is therefore reasonable to expect that the factors which encourage diversification among male-headed households will not operate in the same way, or with the same strength, among female-headed households.

Most quantitative studies of smallholder adaptation treat diversification as one option within a broader menu of strategies, usually alongside improved varieties, changed planting dates and irrigation, and few disaggregate its determinants by the gender of the household head. Studies of diversification in Pakistan have concentrated on flood-prone districts of Khyber Pakhtunkhwa and on vulnerability indices, rather than on the household-level determinants of specific diversification choices in South Punjab. An earlier paper from the same survey examined on-farm adaptation strategies and found that male farmers adopted them with greater confidence than female farmers and that food security was negatively associated with on-farm adaptation (Sheikh et al., 2023). Whether the same pattern holds for diversification, which draws on different resources, has not been tested.

This paper addresses that question. Using primary data from 1,152 small landholder households (974 male-headed and 178 female-headed) in the Multan, Bahawalpur and DG Khan divisions, it estimates the determinants of two diversification-based autonomous adaptation strategies: non-farm engagement and participation in multiple income-generating activities. Binomial logit models are estimated separately for male- and female-headed households in each division and for South Punjab as a whole, using eight groups of explanatory variables: demographic characteristics, human capital, land-related factors, non-land assets and income, access to services, climate change exposure, food security, and exposure to planned (government-led) adaptation. The study contributes to the literature in three ways. It provides a regression-based analysis of diversification determinants specific to South Punjab. It estimates every model separately by gender and by division, which shows where the gender gap in diversification comes from. And it separates non-farm engagement from multiple income-generating activities, which turn out to respond differently to household assets, particularly for women.

The rest of the paper is organized as follows. Section 2 reviews the literature on diversification as an adaptation strategy and on its determinants. Section 3 describes the study area, sampling, variables and econometric model. Section 4 presents and discusses the results. Section 5 concludes with policy implications.

2. Literature Review

2.1 Livelihood Diversification as a Climate Change Adaptation Strategy

In Agrawal and Perrin's (2009) typology, diversification spreads risk across the assets and activities a household depends on. Where on-farm adaptation tries to make a given crop more resilient, diversification reduces the household's dependence on any one crop or on farming as a whole. Ellis (1998) describes rural livelihood diversification as the process through which households construct an increasingly varied portfolio of activities and assets in order to survive and to improve their standard of living. Barrett et al. (2001) distinguish between diversification driven by push factors, such as risk, missing insurance and falling farm returns, and diversification driven by pull factors, such as higher returns in non-farm work. Both kinds are

relevant under climate change: a failed season pushes households to seek other income, while better roads, education and market access pull some members into non-farm employment.

This study measures diversification through two binary outcomes. Non-farm engagement refers to household participation in activities outside agriculture, such as wage labour, trade, transport, services or salaried employment, as a way of earning income that does not depend on the weather. Multiple income-generating activities refers to the household running several income sources at once, across different products, such as combining crops with livestock, dairy, poultry, value-added processing or small enterprises, so that a shock to one product does not remove the household's whole income. The two overlap but are not the same. A household can run several farm-linked income sources without any member working off the farm, and this distinction matters for female-headed households whose mobility outside the home is constrained.

Evidence from Pakistan and elsewhere shows that diversification is a common response to climate stress. In the Morogoro region of Tanzania, households responded to climatic and other pressures by expanding cultivated land, intensifying farming, diversifying livelihoods and migrating for work (Paavola, 2008). In flood-affected districts of Khyber Pakhtunkhwa, a large share of farm households used on-farm and off-farm diversification to manage catastrophic risk, and their decisions depended on socioeconomic, demographic, institutional and risk-perception factors (Shah et al., 2021). In the Mekong Delta, households exposed to salinity intrusion were more likely to pursue off-farm income, and asset endowment, extension services, transport, input access and cooperative membership all increased the extent of livelihood diversification (Ho et al., 2022).

2.2 Empirical Literature on the Determinants of Diversification

Demographic characteristics are standard explanatory variables in adaptation studies. Age is often found to reduce the likelihood of diversification, because older household heads have less physical capacity for non-farm work, are less familiar with new skills, and tend to prefer the security of familiar farm routines. Gebru et al. (2020), studying smallholders in Eastern Tigray, Ethiopia, found that older age reduced the likelihood of adopting combined adaptation packages that included diversification into off-farm and non-farm activities. Household composition matters too. Larger and joint households have more working members who can be assigned to non-farm work while others manage the farm, and Deressa et al. (2009) found household size and characteristics of the household head to be significant determinants of adaptation choice in the Nile Basin of Ethiopia. Van Aelst and Holvoet (2016) showed that marital status shaped women's access to non-farm activities in rural Tanzania much more than it shaped men's.

Human capital is one of the most consistent predictors of non-farm participation. Education opens access to salaried and skilled work and makes it easier to start a business. Deressa et al. (2009) identified education among the strongest determinants of adaptation choice, and Ali and Erenstein (2017), in a study of 950 farmers across Pakistan, found that more educated farmers were more likely to adopt climate risk-coping strategies. Mahmood et al. (2021) found that off-farm income and education were significant predictors of adaptation among rain-fed farmers in Pakistan. The role of farming experience is less clear. Mabe et al. (2014) found that experience increased the adoption of several adaptation strategies in northern Ghana, but experience may also tie farmers more closely to agriculture and reduce their interest in outside work.

Land size, ownership and quality are widely found to increase adaptation. Ali and Erenstein (2017) report that landholding size was strongly associated with all the adaptation methods they examined in Pakistan. Gbetibouo et al. (2010), studying the Limpopo Basin of South Africa, found that farm size, tenure security and off-farm activities all increased farmers' ability to adapt. For diversification specifically, land can act as collateral for credit and as a source of surplus that can be invested in new activities (Tesfahunegn et al., 2016; Kumar et al., 2023; Molla et al., 2023).

Wealth, measured through non-land assets and income, shapes the ability to invest in new income sources. Gebru et al. (2020) found that higher income and better-off wealth status increased the adoption of diversification-based strategies. Ho et al. (2022) similarly report a positive effect of asset endowment on the extent of diversification. Assets may, however, pull in different directions. Livestock, tube wells and tractors can support farm-linked income such as dairy, custom hiring and irrigation services, while reducing the need for household members to look for work off the farm (Swai, 2017; Destaw and Fenta, 2021).

Access to services, including credit, extension advice, surfaced roads and membership of farmer organisations, is one of the most consistent positive predictors in the adaptation literature. Ali and Erenstein (2017) found extension services, paved-road access and association membership to be positively associated with adaptation in Pakistan, and Ojo et al. (2021) showed that access to credit was closely tied to farmers' choice of adaptation strategies in South Africa. Roads and credit are especially relevant for non-farm engagement because they determine whether household members can reach employment and whether a small enterprise can be financed. Shah et al. (2021) listed the lack of credit, training, market and road infrastructure among the main barriers to diversification in flood-prone Pakistan.

Farmers' experience of climate change, including rising temperatures, changing rainfall and a shifting monsoon onset, generally increases their willingness to adapt (Deressa et al., 2009; Abid et al., 2019). Gebru et al. (2020) found that farmers who perceived climate change were considerably more likely to diversify. Food security may work in either direction. Food-insecure households may be pushed into non-farm work out of necessity, while food-secure households have the stability and savings needed to invest in new ventures (Mabe et al., 2014; Marie et al., 2020). Finally, a smaller body of work examines how government-led planned adaptation interacts with farmers' own choices. Where farmers receive adaptation information, training and support through extension services and the media, most studies report that planned and autonomous adaptation reinforce each other (Ali and Erenstein, 2017; Mahmood et al., 2021).

2.3 Gender, Diversification and Climate Change Adaptation

Gender-focused studies of adaptation have mostly examined on-farm strategies, and those that consider diversification are often qualitative or descriptive. Using national household surveys from Mexico, Peru and Brazil, Andersen et al. (2017) found that income diversification was closely linked to household resilience and that female-headed households were not necessarily more vulnerable than male-headed ones once income diversity was taken into account.

The broader literature from developing countries finds that male farmers generally report higher adoption rates across adaptation strategies, which is usually attributed to women's more limited access to land, credit, information and extension services (Deressa et al., 2009; Atube et al.,

2021). In Pakistan, women's own perceptions of climate change and their coping strategies have been documented (Batool et al., 2018), but quantitative evidence on what determines diversification among female-headed farm households is scarce.

Three gaps motivate the present study. First, regression-based evidence on the determinants of diversification is limited, and diversification is often included only as one category within a wider adaptation index. Second, few studies estimate the determinants of diversification separately for male- and female-headed households, and fewer still have a sample large enough to do so across several divisions. Third, no known study has examined household-level determinants of diversification in South Punjab, a region that is highly exposed to climate variability. This paper addresses all three using primary survey data and binomial logit models estimated separately by gender across three divisions.

3. Materials and Methods

3.1 Study Area

South Punjab consists of three administrative divisions, Multan, Bahawalpur and DG Khan, in Pakistan's most populous province. The region lies at the edge of the monsoon zone. Summer temperatures on the plains reach the mid-30s °C and winter temperatures fall to about 10 °C, and agriculture, supported by river and canal irrigation, is the main source of rural livelihood. Multan Division (Multan, Khanewal, Vehari and Lodhran districts) had a population of about 12.27 million in the 2017 census. Bahawalpur Division (Bahawalpur, Bahawalnagar and Rahim Yar Khan districts), which includes the arid Cholistan Desert, had about 11.45 million. DG Khan Division (DG Khan, Layyah, Muzaffargarh and Rajanpur districts), with sandy soils, summer dust storms and temperatures ranging from about 4 °C in winter to 42 °C in summer, had about 11.02 million (Figure 1). All three divisions are exposed to floods, droughts and rising temperatures, and all have limited non-farm employment outside the main towns, which makes them a suitable setting for studying diversification as an adaptation strategy (Sheikh et al., 2023).



Figure 1: Map of South Punjab

3.2 Data Source and Sampling Procedure

Primary data were collected through a closed-ended questionnaire survey in eleven districts across the three divisions. The sample size was determined using the Krejcie and Morgan (1970) procedure, which gives a sample of 384 at the 95% confidence level for populations of one million or more. This number was applied to each division and allocated to its districts in proportion to the area under cultivation (Table 1). The final sample comprises 1,152 small landholder households, 384 from each division, of which 974 are male-headed and 178 are female-headed.

Table 1: Sample Size Determination by Division and District

Division	District	Sample Size (Krejcie & Morgan)	Sample Taken (Actual)
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). The Krejcie and Morgan (1970) sample of 384 per division was allocated to districts in proportion to cultivated area.

3.3 Diversification Adaptation Strategies (Dependent Variables)

Two binary dependent variables capture diversification-based autonomous adaptation. Non-Farm Engagement (NFE) equals 1 if the household engages in non-farm activities to secure income that does not depend on agriculture, and 0 otherwise. Multiple Income-Generating Activities (MIGA) equals 1 if the household engages in several income-generating activities across different products in order to spread the risk of climate variability, and 0 otherwise.

3.4 Independent Variables

Eight groups of explanatory variables are used, several of them constructed as indices through Principal Component Analysis (PCA): (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 levelling); (iv) non-land assets and income: a non-land asset index (tractor, tube well, car and livestock ownership) and monthly household income; (v) access to services: an index combining access to credit, contact with agricultural advisors, access to a surfaced road, membership of a farming organisation and use of solar energy for the tube well; (vi) climate change exposure: an

index of farmers' reported experience of climate change, rising temperature, changing rainfall and a shift in monsoon onset; (vii) food security: a nine-indicator index covering reliance on self-farmed food, sale and barter of crops for food, past food shortages, access to affordable food, food waste, confidence in food supply for the next six months and reliance on food assistance; and (viii) planned climate change adaptation: a seven-indicator index capturing farmers' exposure to and use of government adaptation strategies, information channels and training. Table 2 summarises the definitions and measurement of all variables.

Table 2: Variables, Abbreviations and Measurement

Variable	Abbreviation	Measurement
Dependent Variables		
Non-Farm Engagement	NFE	1 = engages in non-farm activities, 0 = no
Multiple Income-Generating Activities	MIGA	1 = engages in several income-generating activities across products, 0 = no
Demographics		
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
Land Owner	LO	1 = yes, 0 = no
Land Quality Index	LQI	Continuous (PCA index, 4 indicators)
Non-Land Assets and 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 Climate Change Adaptation Index	PCCAS	Continuous (PCA index, 7 indicators)

3.5 Econometric Model

Because both dependent variables are binary, the study uses the binomial logit model, which, unlike the linear probability model, keeps predicted probabilities within the [0, 1] interval. The probability that household *i* adopts a given diversification strategy is specified as a logistic function of the vector of explanatory variables *X_i*:

$$P(Y = 1 | X) = 1 / [1 + \exp(-(\beta_0 + \beta'X_i))] \quad (1)$$

which gives the estimable log-odds 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 and income, service-access, climate-exposure, food-security and planned-adaptation variables, and β is the vector of coefficients. Logit coefficients show the direction and significance of an effect but not its size in probability terms, so marginal effects are also reported. The marginal effect gives the change in the probability of adoption associated with a one-unit change in a regressor, holding the other variables constant:

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

For the non-farm engagement model, the full specification is:

$$NFE_i = \beta_0 + \beta_1 AGE_i + \beta_2 MSI + \beta_3 FSI + \beta_4 DEPB_i + \beta_5 FEXPI + \beta_6 EDUI + \beta_7 LSI + \beta_8 LO_i + \beta_9 LQI_i + \beta_{10} NLA_i + \beta_{11} INCI + \beta_{12} ASI_i + \beta_{13} CCI_i + \beta_{14} FSI_i + \beta_{15} PCCAS_i + \varepsilon_i \quad (4)$$

The multiple income-generating activities model uses the same regressors with $MIGAI_i$ as the dependent variable. Both models are estimated separately for male- and female-headed households within each division and for South Punjab as a whole, giving eight estimates per strategy.

4. Results and Discussion

4.1 Adoption Patterns of Diversification Strategies

Table 3 reports adoption rates for the two diversification strategies by gender and division. Across South Punjab, 55.2% of households engaged in non-farm activities. Adoption was higher among male-headed households (56.7%) than female-headed households (47.2%), and the gap of roughly nine to eleven percentage points appears in every division. Non-farm engagement was highest among male-headed households in Multan Division (60.0%) and lowest among female-headed households in DG Khan Division (41.8%).

Participation in multiple income-generating activities was slightly more common, at 59.4% of households overall, and showed no gender gap at the provincial level (59.3% of male-headed and 59.6% of female-headed households). In Multan and DG Khan divisions, female-headed households were more likely than male-headed households to run several income sources (62.7% against 61.2% in Multan and 63.6% against 57.8% in DG Khan), while in Bahawalpur the pattern reversed (53.1% against 59.1%). These figures suggest that the gender gap in diversification lies mainly in access to work outside the farm rather than in the willingness to spread income across several activities. The regression results below help explain why.

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

Strategy		South Punjab	S. Punjab (M)	S. Punjab (F)	Multan (M)	Multan (F)	Bahawalpur (M)	Bahawalpur (F)	DG Khan (M)	DG Khan (F)
Non-Farm Engagement	Yes	636 (55.2)	552 (56.7)	84 (47.2)	195 (60.0)	29 (49.2)	189 (59.1)	32 (50.0)	168 (51.1)	23 (41.8)
	No	516 (44.8)	422 (43.3)	94 (52.8)	130 (40.0)	30 (50.8)	131 (40.9)	32 (50.0)	161 (48.9)	32 (58.2)
Multiple Income-Generating Activities	Yes	684 (59.4)	578 (59.3)	106 (59.6)	199 (61.2)	37 (62.7)	189 (59.1)	34 (53.1)	190 (57.8)	35 (63.6)
	No	468 (40.6)	396 (40.7)	72 (40.4)	126 (38.8)	22 (37.3)	131 (40.9)	30 (46.9)	139 (42.2)	20 (36.4)

Note: Figures are frequency counts with column percentages in parentheses. M = male-headed, F = female-headed households. n = 1,152 (974 male-headed, 178 female-headed).

Figure 2 shows the same adoption rates graphically. The male–female gap in non-farm engagement is visible in every division, while for multiple income-generating activities the bars for the two groups are close or reversed.

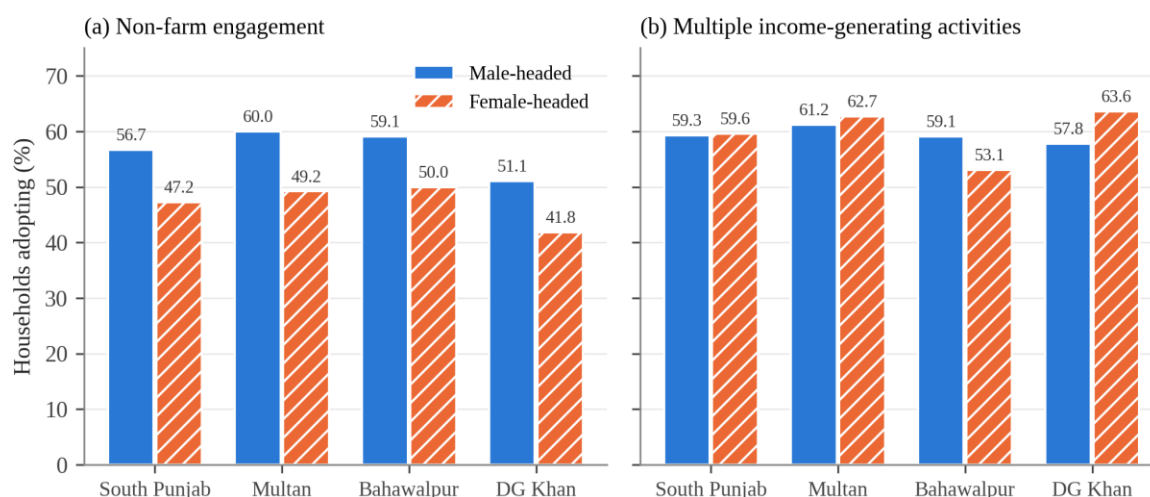


Figure 2: Adoption of diversification strategies by gender and division (% of households)

Source: Survey data (Table 3).

4.2 Determinants of Diversification Strategies

Tables 4 and 5 report the binomial logit coefficients, p-values (in parentheses) and marginal effects (in brackets) for non-farm engagement and multiple income-generating activities, estimated separately for male- and female-headed households in each division and for South Punjab as a whole. The results are discussed by variable group in Section 4.3.

Table 4: Determinants of Non-Farm Engagement (NFE), Binomial Logit Results

Variables	MTN-M	MTN-F	BWP-M	BWP-F	DGK-M	DGK-F	SPB-M	SPB-F
Demographics								
Age	0.0123 (0.0506) [0.0030] 2.1089	-0.0858 (0.0178) [-0.0215] 0.9508	-0.0006 (0.0073) [-0.0001] 1.4743	-0.2378 (0.0295) [-0.0595] 2.8969	-0.6650 (0.0018) [-0.1662] 1.7447	-0.0677 (0.0031) [-0.0165] 1.3181	-0.2596 (0.0007) [-0.0637] 1.8926	-0.7588 (0.0011) [-0.1891] 1.1940
Marital Status	(0.0001) [0.5061] 0.4602	(0.0304) [0.2376] 1.0754	(0.0037) [0.3565] 0.3264	(0.0195) [0.7242] 4.1412	(0.0002) [0.4360] 0.5508	(0.0016) [0.3207] 0.2004	(0.0000) [0.4647] 0.1677	(0.0178) [0.2976] 1.0584
Family System	(0.0038) [0.1105] 1.1526	(0.0087) [0.2688] 1.4058	(0.0016) [0.0789] 0.4293	(0.0066) [1.0353] 6.8286	(0.0001) [0.1376] 0.6916	(0.0005) [0.0488] 0.6566	(0.0005) [0.0412] 0.7672	(0.0161) [0.2638] 0.4595
Dependency Burden	(0.0641) [0.2766]	(0.0391) [0.3514]	(0.0026) [0.1038]	(0.1027) [1.7071]	(0.0001) [0.1728]	(0.0033) [0.1597]	(0.0005) [0.1884]	(0.0002) [0.1145]
Human Capital								
Farming Experience	0.0298 (0.0537) [0.0071] 0.0328	0.1028 (0.0492) [0.0257] 0.0147	-0.0259 (0.0078) [-0.0063] 0.0045	-0.2984 (0.0282) [-0.0746] 0.3177	-0.1110 (0.0001) [-0.0277] 0.0601	-0.1576 (0.0274) [-0.0384] 0.1139	-0.1805 (0.0001) [-0.0443] 0.1572	-0.1122 (0.0006) [-0.0280] 0.7631
Education	(0.3157) [0.0079]	(0.0014) [0.0037]	(0.0009) [0.0011]	(0.0229) [0.0794]	(0.0005) [0.0150]	(0.0036) [0.0277]	(0.0004) [0.0386]	(0.0006) [0.1902]
Land-Related Variables								
Land Size	0.0154 (0.0080) [0.0037] 0.8666	0.1372 (0.0387) [0.0343] 0.4625	0.0437 (0.0016) [0.0106] 0.4608	0.6832 (0.0335) [0.1708] 2.1269	0.0718 (0.0003) [0.0179] 0.2241	0.0243 (0.0094) [0.0059] 1.3787	0.7639 (0.0009) [0.1876] 0.4187	0.4086 (0.0009) [0.1018] 0.3325
Land Owner	(0.0067) [0.2080] 0.0329	(0.0294) [0.1156] 1.8264	(0.0057) [0.1114] 1.4927	(0.0181) [0.5317] 5.0795	(0.0014) [0.0560] 0.2921	(0.2246) [0.3355] 1.8708	(0.0009) [0.1028] 0.4402	(0.0007) [0.0829] 2.1565
Land Quality Index	(0.0026) [0.0079]	(0.0704) [0.4565]	(0.0284) [0.3609]	(0.0709) [1.2699]	(0.0028) [0.0730]	(0.0014) [0.4552]	(0.0008) [0.1081]	(0.0545) [0.5374]
Non-Land Assets and Income								
Non-Land Assets Index	0.1699 (0.0046) [0.0408] 0.0821	-0.0744 (0.0656) [-0.0186] 0.0432	0.0524 (0.0064) [0.0127] 0.0793	-7.9127 (0.0246) [-1.9782] 0.8567	1.5831 (0.0086) [0.3956] 0.0604	-0.6482 (0.0056) [-0.1577] 0.2086	0.5405 (0.0011) [0.1327] 0.1179	-1.0840 (0.0025) [-0.2701] 0.2634
Income	(0.0082) [0.0197]	(0.9034) [0.0108]	(0.0065) [0.0192]	(0.0685) [0.2142]	(0.0042) [0.0151]	(0.0002) [0.0507]	(0.8103) [0.0289]	(0.0023) [0.0656]
Access to Services								
Access to Services Index	1.2571 (0.0542) [0.3017]	3.6745 (0.0978) [0.9184]	0.9732 (0.1012) [0.2353]	3.2501 (0.0378) [0.8125]	0.9833 (0.0961) [0.2457]	2.8417 (0.0097) [0.6914]	1.1574 (0.0011) [0.2842]	3.3427 (0.0032) [0.8330]
Climate Change								
Climate Change Index	0.2680 (0.0021) [0.0643]	0.6146 (0.0652) [0.1536]	0.0435 (0.0072) [0.0105]	6.3296 (0.0060) [1.5824]	0.1923 (0.0013) [0.0481]	0.3230 (0.0025) [0.0786]	0.8554 (0.0000) [0.2100]	1.0477 (0.0852) [0.2611]
Food Security								
Food Security Index	4.0470 (0.0000) [0.9713]	2.4768 (0.0486) [0.6190]	3.1524 (0.0000) [0.7622]	0.8695 (0.0926) [0.2174]	0.7142 (0.0081) [0.1785]	3.3260 (0.0087) [0.8092]	2.6681 (0.0000) [0.6551]	2.5145 (0.0332) [0.6266]
Planned Climate Change Adaptation								
Planned Adaptation Index	1.6472 (0.0000) [0.3953]	0.3390 (0.0847) [0.0847]	1.2613 (0.1312) [1.3050]	2.0685 (0.0073) [0.5171]	1.2361 (0.0031) [0.3089]	2.3289 (0.0000) [0.5667]	1.1916 (0.0013) [0.2926]	0.9813 (0.0000) [0.2446]

Note: Cell values are logit coefficients, with p-values in parentheses and marginal effects in square brackets. MTN = Multan, BWP = Bahawalpur, DGK = DG Khan, SPB = South Punjab; M = male-headed, F = female-headed households.

Table 5: Determinants of Multiple Income-Generating Activities (MIGA), Binomial Logit Results

Variables	MTN-M	MTN-F	BWP-M	BWP-F	DGK-M	DGK-F	SPB-M	SPB-F
Demographics								
Age	0.0122 (0.0086) [0.0029]	-0.0759 (0.0171) [-0.0177]	-0.2207 (0.0073) [-0.0534]	-0.0789 (0.0197) [-0.0197]	-0.0186 (0.0024) [-0.0455]	-0.3216 (0.0064) [-0.0744]	-0.1935 (0.0123) [-0.0467]	-0.5739 (0.0034) [-0.1382]
Marital Status	0.7607 (0.0605) [0.1806]	0.2049 (0.0123) [0.0479]	0.6451 (0.0001) [0.1560]	1.1460 (0.0102) [0.2854]	0.4561 (0.0002) [0.1113]	0.7799 (0.0027) [0.1805]	0.7799 (0.0012) [0.1882]	0.4553 (0.0003) [0.1097]
Family System	0.1021 (0.0025) [0.0242]	0.4494 (0.0921) [0.1051]	0.0249 (0.0044) [0.0060]	0.6026 (0.0776) [0.1501]	0.2024 (0.0046) [0.0494]	1.0321 (0.0042) [0.2388]	0.2415 (0.0006) [0.0583]	0.3021 (0.0005) [0.0728]
Dependency Burden	0.7796 (0.2199) [0.1851]	0.8689 (0.0555) [0.2032]	0.5986 (0.0067) [0.1447]	6.0928 (0.0646) [1.5172]	0.2522 (0.0096) [0.0615]	1.7817 (0.5064) [0.4123]	0.1699 (0.0060) [0.0410]	1.4015 (0.0070) [0.3376]
Human Capital								
Farming Experience	0.0094 (0.0049) [0.0022]	0.1210 (0.0162) [0.0283]	-0.0133 (0.0041) [-0.0032]	-0.0460 (0.0896) [-0.0115]	-0.0130 (0.0016) [-0.0317]	-0.0019 (0.0079) [-0.0004]	-0.2779 (0.0009) [-0.0670]	-0.4847 (0.0648) [-0.1168]
Education	0.0460 (0.0017) [0.0109]	0.0569 (0.0414) [0.0133]	0.0133 (0.0027) [0.0032]	0.2444 (0.0194) [0.0609]	0.0425 (0.1545) [0.1037]	0.0653 (0.0038) [0.0151]	0.2907 (0.0006) [0.0701]	0.0775 (0.0033) [0.0187]
Land-Related Variables								
Land Size	0.1584 (0.0015) [0.0376]	0.2476 (0.0551) [0.0579]	0.1079 (0.0307) [0.0261]	0.1831 (0.0293) [0.0456]	0.1067 (0.0271) [0.0260]	0.1419 (0.0088) [0.0328]	0.1083 (0.0001) [0.0261]	0.0108 (0.0042) [0.0026]
Land Owner	0.6191 (0.0398) [0.1470]	2.1957 (0.0911) [0.5134]	0.7695 (0.0106) [0.1860]	2.4889 (0.0121) [0.6198]	0.4242 (0.0043) [0.1035]	0.1513 (0.0891) [0.0350]	0.6407 (0.0002) [0.1546]	1.4277 (0.0076) [0.3439]
Land Quality Index	0.2956 (0.0085) [0.0702]	1.1345 (0.0719) [0.2653]	0.2085 (0.1395) [0.0504]	1.4586 (0.4822) [0.3632]	0.9424 (0.0053) [0.2299]	0.4222 (0.0075) [0.0977]	0.3218 (0.0002) [0.0776]	0.8317 (0.0009) [0.2003]
Non-Land Assets and Income								
Non-Land Assets Index	0.7698 (0.0028) [0.1827]	0.3877 (0.0245) [0.0907]	0.3224 (0.0025) [0.0779]	1.1819 (0.0098) [0.2943]	1.1292 (0.0554) [0.2755]	0.3840 (0.0721) [0.0888]	0.6920 (0.0054) [0.1670]	0.3532 (0.0042) [0.0851]
Income	0.2235 (0.0011) [0.0530]	0.2424 (0.0484) [0.0567]	0.0099 (0.0075) [0.0024]	0.5949 (0.0817) [0.1481]	0.1695 (0.0440) [0.0414]	0.0777 (0.0009) [0.0179]	0.1114 (0.0172) [0.0269]	0.1513 (0.0051) [0.0364]
Access to Services								
Access to Services Index	0.4964 (0.0029) [0.1178]	2.9082 (0.0005) [0.6801]	0.5403 (0.0064) [0.1306]	3.0960 (0.0152) [0.7710]	0.0883 (0.0098) [0.2155]	0.8529 (0.0422) [0.1973]	0.2271 (0.0003) [0.0548]	0.7026 (0.0064) [0.1692]
Climate Change								
Climate Change Index	0.6831 (0.0032) [0.1622]	1.6077 (0.1511) [0.3759]	0.9358 (0.0423) [0.2263]	2.9002 (0.0488) [0.7222]	0.9509 (0.0337) [0.2320]	1.4052 (0.0666) [0.3251]	0.7718 (0.0000) [0.1862]	1.4335 (0.0169) [0.3453]
Food Security								
Food Security Index	2.8901 (0.0003) [0.6861]	4.0949 (0.0531) [0.9576]	0.8708 (0.0032) [0.2105]	6.6686 (0.0100) [1.6606]	1.5071 (0.0357) [0.3677]	1.2789 (0.0418) [0.2959]	1.5705 (0.0002) [0.3789]	3.4882 (0.0013) [0.8402]
Planned Climate Change Adaptation								
Planned Adaptation Index	2.0971 (0.0001) [0.4978]	0.7975 (0.1522) [0.1865]	0.8058 (0.0095) [0.1948]	1.8607 (0.0123) [0.4634]	0.0632 (0.0350) [0.0154]	1.9631 (0.0640) [0.4543]	0.3691 (0.0000) [0.0890]	0.4099 (0.0034) [0.0987]

Note: Cell values are logit coefficients, with p-values in parentheses and marginal effects in square brackets. MTN = Multan, BWP = Bahawalpur, DGK = DG Khan, SPB = South Punjab; M = male-headed, F = female-headed households.

4.3 Discussion

4.3.1 Demographic Factors

Age

Age is negatively associated with both non-farm engagement and multiple income-generating activities for male and female farmers in Bahawalpur Division, DG Khan Division and South Punjab as a whole. In Multan Division the relationship is positive for male farmers but negative for female farmers. At the provincial level, the marginal effect of age on non-farm engagement is -0.189 for women against -0.064 for men (Table 4), so the age penalty is about three times steeper for female-headed households. Older farmers face physical limits on the kind of manual non-farm work that is available in rural South Punjab, may be less familiar with the skills demanded outside agriculture, and tend to prefer the security of familiar farm routines over the uncertainty of new income sources. This result agrees with Gebru et al. (2020), who found that older age reduced the adoption of adaptation packages that included off-farm and non-farm diversification in Ethiopia, and with Destaw and Fenta (2021). The positive effect among male farmers in Multan may reflect the division's larger urban centre and better-developed markets, where older men with accumulated savings and contacts can move into trade or services rather than wage labour.

Marital Status

Married male and female farmers are more likely than unmarried farmers to engage in non-farm activities and to run multiple income-generating activities in all divisions. The effect is large: at the provincial level, being married raises the probability of non-farm engagement by 46.5 percentage points for men and 29.8 points for women. Marriage allows a division of labour within the household, in which one spouse manages the farm while the other takes up outside work or a second enterprise, and it combines the skills, savings and social contacts of two families. This result is consistent with Van Aelst and Holvoet (2016), who found in rural Tanzania that marital status was an important factor in determining women's access to adaptation strategies, including non-farm activities, and with Swai (2017).

Family System

Households living in a joint family system are more likely to adopt both diversification strategies in all divisions and for both genders. A joint family includes several working-age adults, so some members can take up non-farm employment while others continue farming, and the extended family provides a safety net that makes it less risky to try a new activity. The effect is particularly strong for female-headed households in Bahawalpur Division. The reported marginal effect for non-farm engagement there (1.04) is above the theoretical bound for a change in probability, which reflects the small sub-sample, and it should be read only as indicating a very strong effect. The result agrees with Swai (2017), Gebru et al. (2020) and Batool et al. (2018), who link larger households and shared labour to more diversified livelihoods.

Dependency Burden

A higher dependency burden is positively associated with both diversification strategies for male and female farmers across all divisions, although the coefficient is not statistically significant for

multiple income-generating activities among male farmers in Multan and female farmers in DG Khan, or for non-farm engagement among female farmers in Bahawalpur. When a larger share of household members do not earn, the pressure to find additional income increases. This is a push factor in the sense of Barrett et al. (2001): households with many dependents cannot rely on a single, weather-dependent crop income and look for wage work or a second income source. The effect is stronger for women (marginal effects of 0.34 against 0.04 for multiple income-generating activities at the provincial level), which suggests that female heads of household with many dependents are especially likely to combine several small income sources.

4.3.2 Human Capital

Farming Experience

Farming experience is negatively associated with both strategies in Bahawalpur Division, DG Khan Division and South Punjab, but positively associated with both in Multan Division, for male and female farmers alike. In most of the region, farmers with longer experience appear to be more committed to agriculture and to farm-specific skills, which reduces both the need and the opportunity to look for income elsewhere. In Multan, experienced farmers may instead be able to transfer their management and marketing knowledge to related enterprises such as input trading, produce marketing or livestock. The mixed direction of this variable is consistent with the literature. Mabe et al. (2014) found a positive effect of experience on several adaptation strategies in Ghana, while other studies suggest that farm-specific experience ties households more closely to agriculture (Swai, 2017; Gebru et al., 2020).

Education

Education is positively associated with both diversification strategies across all divisions and for both genders, though the coefficient is not significant for non-farm engagement among male farmers in Multan or for multiple income-generating activities among male farmers in DG Khan. The gender difference is notable. At the provincial level, the marginal effect of schooling on non-farm engagement is 0.190 for women, nearly five times the 0.039 estimated for men. For women in rural South Punjab, education appears to be one of the few routes into non-farm work such as teaching, health work, tailoring or home-based enterprise. The positive effect of education agrees with Deressa et al. (2009), Ali and Erenstein (2017) and Mahmood et al. (2021), all of whom identify education as a strong determinant of adaptation.

4.3.3 Land-Related Factors

Land size, land ownership and the land quality index are all positively associated with non-farm engagement and multiple income-generating activities for male and female farmers in all divisions. A few coefficients fall short of significance: land ownership for non-farm engagement among women in DG Khan, and land quality for multiple income-generating activities among both genders in Bahawalpur. Larger and better-quality holdings produce surpluses that can be invested in new activities, while ownership provides collateral for credit and the security needed to commit household labour and savings elsewhere. Land ownership has a particularly strong effect on multiple income-generating activities among female-headed households, raising the probability by 34.4 percentage points at the provincial level against 15.5 points for men. Owning land appears to give women a base from which to add livestock, dairy or other farm-linked

income. These results agree with Ali and Erenstein (2017), who found landholding size strongly associated with adaptation in Pakistan, and with Gbetibouo et al. (2010), who found farm size and tenure security to increase adaptive capacity in South Africa.

4.3.4 Non-Land Assets and Income

The non-land asset index shows the sharpest gender contrast in the study. For male farmers it is positively associated with both non-farm engagement and multiple income-generating activities in every division. For female farmers it is negatively associated with non-farm engagement in all three divisions and in South Punjab, but positively associated with multiple income-generating activities. At the provincial level, the marginal effect of the index on non-farm engagement is -0.270 for women and $+0.133$ for men.

The index combines tractor, tube well, car and livestock ownership. For men, these assets can be turned into non-farm income directly: a car or tractor can be used for transport or custom hiring, and ownership of such assets often signals the savings and contacts needed to start a business. For women, the same assets appear to keep household labour on the farm. A female-headed household that owns livestock or a tube well can earn from dairy, poultry, vegetable growing or selling irrigation water, all of which can be managed close to home, and so has less reason to seek work outside it. Given the constraints on women's mobility in rural Punjab, this is a plausible explanation for why assets raise women's participation in multiple income-generating activities while lowering their non-farm engagement. The positive effect of assets for men agrees with Ho et al. (2022) and Gebru et al. (2020), and the substitution between farm-linked and outside income for women is consistent with Kumar et al. (2023) and Molla et al. (2023).

Household income is positively associated with both strategies for male and female farmers in all divisions. It is not significant for non-farm engagement among women in Multan or among men in South Punjab as a whole. Higher income provides the capital to start new activities and to pay for the training, transport and inputs they require, which agrees with Gebru et al. (2020) and Destaw and Fenta (2021).

4.3.5 Access to Services

The access to services index is positively associated with both diversification strategies for male and female farmers across all divisions. It is not significant for non-farm engagement among male farmers in Bahawalpur. The effect is much larger for women. At the provincial level, its marginal effect on non-farm engagement is 0.833 for female-headed households against 0.284 for male-headed households, the largest of any variable in the women's model, and the marginal effects for women in Multan (0.92), Bahawalpur (0.81) and DG Khan (0.69) are all large. Credit allows households to finance a small enterprise, surfaced roads let household members reach work in nearby towns, contact with agricultural advisors brings information about markets and opportunities, and membership of farming organisations widens social networks. Women start from a lower base in each of these, so improvements have a larger effect on their options. The result is consistent with Ali and Erenstein (2017), who found extension, paved roads and association membership to support adaptation in Pakistan, with Ojo et al. (2021) on the role of credit, and with Shah et al. (2021), who identified the lack of credit, training and road and market infrastructure as the main barriers to diversification in flood-prone Pakistan.

4.3.6 Climate Change Exposure

The climate change index is positively associated with both diversification strategies for male and female farmers in all divisions. The only coefficient that is not significant is for multiple income-generating activities among female farmers in Multan. Farmers who have experienced rising temperatures, changing rainfall and a shift in monsoon onset appear more willing to reduce their dependence on crop income by working outside agriculture or adding new income sources. This agrees with Gebru et al. (2020), who found that perception of climate change greatly increased diversification in Ethiopia, and with Abid et al. (2019), who found that accurate perceptions of climate change led to stronger adaptation intentions among farmers in Punjab.

4.3.7 Food Security

The food security index is positively and significantly associated with both diversification strategies for male and female farmers in every division. Its marginal effects are among the largest in the study. At the provincial level they are 0.66 for men and 0.63 for women on non-farm engagement, and 0.38 for men and 0.84 for women on multiple income-generating activities, the largest of any variable in both multiple income-generating activities models. Food-secure households have the stability and the time needed to invest in new activities, and they are not forced to spend all their labour and savings on securing the next meal. Diversification in turn supports food security by providing income when crops fail. This result is consistent with Mabe et al. (2014) and Marie et al. (2020).

The positive direction here contrasts with the negative association between food security and on-farm adaptation reported from the same survey (Sheikh et al., 2023). Taken together, the two results suggest that food-insecure households concentrate their efforts on intensifying production on their own farms, while food-secure households are more likely to reduce risk by spreading their income beyond the farm. Food security thus appears to shift households from one kind of adaptation to another rather than simply increasing or decreasing adaptation overall.

4.3.8 Planned Climate Change Adaptation Strategies

The planned adaptation index, which measures farmers' exposure to government adaptation information, training and support, is positively associated with both diversification strategies for male and female farmers in all divisions. It is not significant for non-farm engagement among male farmers in Bahawalpur or for multiple income-generating activities among female farmers in Multan. The result indicates that government-led adaptation complements farmers' own diversification choices rather than replacing them. Information delivered through mobile phones, radio, television and the agriculture department makes farmers more aware of climate risks and of the value of not depending on a single crop, which appears to encourage diversification. This complementarity is consistent with Ali and Erenstein (2017) and Mahmood et al. (2021), who found that formal institutional support, including climate risk training and digital extension, strengthened farmers' adaptation in Pakistan.

5. Conclusion and Policy Implications

This study examined the gender-differentiated determinants of diversification-based climate change adaptation, namely non-farm engagement and multiple income-generating activities,

among 1,152 small landholder households in the Multan, Bahawalpur and DG Khan divisions of South Punjab. Female-headed households were about ten percentage points less likely than male-headed households to engage in non-farm work, but equally likely to run several income-generating activities. Binomial logit models estimated separately by gender and division show that marital status, joint family structure, dependency burden, education, land size, land ownership, land quality, income, access to services, climate change exposure, food security and exposure to planned adaptation are positively associated with both strategies in most specifications. Age and farming experience are negatively associated with diversification outside Multan Division. The non-land asset index raises both strategies for men but lowers non-farm engagement for women, while still raising their participation in multiple income-generating activities.

Several policy implications follow. First, the gender gap in diversification is a gap in access to work outside the farm, not in the willingness to diversify. Programmes for female-headed households should therefore support income sources that can be managed close to home, such as livestock, dairy, poultry, kitchen gardening and small-scale processing, while also removing the barriers that keep women out of non-farm work. Second, access to services and education have much larger effects on women's non-farm engagement than on men's. Extending credit to women without land collateral, improving rural roads and transport, bringing women into farmer organisations and ensuring that extension services reach female farmers are likely to be among the most effective ways to widen their options. Vocational training and adult education for rural women would support the same goal. Third, because food security is positively associated with diversification, food safety nets and diversification support are complements. Households that are food-insecure are less able to diversify and will tend to fall back on on-farm intensification, so social protection can be seen as part of adaptation policy rather than separate from it. Fourth, the positive association between planned adaptation and both strategies indicates that government information and training programmes support farmers' own diversification efforts. Their reach should be extended, and their content should include advice on non-farm and farm-linked income sources as well as on crop management. Finally, older and more experienced farmers are less likely to diversify outside Multan Division, so programmes aimed at them should build on existing farm skills, for example through livestock and value addition, rather than assume a move into non-farm employment.

The findings are specific to the agroecological and socioeconomic conditions of South Punjab and should be generalised with care. The sample of female-headed households in each division is small (55 to 64 households), which makes some division-level estimates for women imprecise, and the cross-sectional data do not allow causal effects to be identified. Future research could measure diversification as a continuous index of income shares rather than as binary choices, examine how diversification interacts with the on-farm, storage, common pooling and mobility strategies in Agrawal and Perrin's (2009) typology, and follow households over time to see how diversification changes as planned adaptation programmes expand.

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