frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 05 January 2023
DOI 10.3389/fenvs.2022.857082

OPEN ACCESS

EDITED BY
Fei Tian,
China Agricultural University, China

REVIEWED BY
Subash Surendran Padmaja,
National Institute for Agricultural Economics and Policy Research (NIAP), India
Keshav Lall Maharjan,
Hiroshima University, Japan

*CORRESPONDENCE
Hengyun Ma,
h.y.ma@163.com

SPECIALTY SECTION
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

RECEIVED 18 January 2022
ACCEPTED 18 November 2022
PUBLISHED 05 January 2023

CITATION
Ahmad MI, Oxley L, Ma H and Liu R (2023), Does rural livelihood change? Household capital, climate shocks and farm entry-exit decisions in rural Pakistan.
Front. Environ. Sci. 10:857082.
doi: 10.3389/fenvs.2022.857082

Does rural livelihood change? Household capital, climate shocks and farm entry-exit decisions in rural Pakistan

Muhammad Irshad Ahmad[1], Les Oxley[2], Hengyun Ma[1]* and Ruifeng Liu[1]

[1]College of Economics and Management, Henan Agricultural University, Zhengzhou, Henan, China, [2]School of Accounting, Economics and Finance, University of Waikato, Hamilton, Waikato, New Zealand

Agriculture is a primary source of livelihoods in developing countries. The process of entry and exit of farming activities continues to play an important role in maintaining competition in agriculture and allocating resources between agriculture and other sectors. However, climate changes and other economic and social shocks have been severely affecting farmers' livelihoods. This article examines rural household livelihood transition in the context of farm entry and exit decisions in rural Pakistan. Using 1867 rural household survey data, we brought insights into how livelihood assets, climate shocks, climate investment and locational characteristics affect their farm entry and exit decisions. The results indicate that the proportion of farm entry (24%) was higher than that of farm exit (15%). The major factors were crop inputs using as credit with a huge markup, crop inputs sold by farmers on net cash in financial crisis, climate shocks and poor climate investment that contributed to farm exit. They were household head characteristics, land ownership (family farm), and livestock ownership that increased the likelihood of farm entry decisions. Farm exit decisions were significantly and positively associated with household migration status, irrigation water shortage, off-farm income, crop input used as credit, crop diseases, climate shocks and lack of local government role in sharing climate knowledge. Furthermore, Propensity Score Matching (PSM) results found that the entry decision significantly decreases household income, while the exit decision significantly increases household income and food security status. These findings provide insights into farm entry and exit for those who are planning livelihood transition, and offer recommendations on how to overcome the constraints faced by farming businesses, agricultural sustainability, self-sufficiency and food security during the transition nationally and internationally.

KEYWORDS

livelihood assets, farm entry, farm exit, livelihoods transition, off-farm work, on-farm work, farmer wellbeing

1 Introduction

Farm entry and exit are a process of livelihood diversification or transition in the agricultural sector, which contributes to global competitiveness of agriculture and efficient resources allocation between agriculture and other sectors in the economy (Binswanger-Mkhize, 2013). More than 2.5 billion out of the three billion rural population deriving their livelihoods from agriculture (FAO, 2021). However, the dwindling size of agricultural land, increasing population, low productivity and hostile agro-ecological factors often result in extreme income variability in agriculture. In response, rural households often use farm entry and exit to diversify their livelihood activities and smooth income variability. Off-farm livelihood opportunities in rural areas often play an important role in reducing food insecurity (Barrett et al., 2001). However, farm exit in the form of shifting from on-farm to off-farm activities does not necessarily create positive outcomes in terms of either reducing poverty or increasing incomes, particularly in developing agrarian countries. In some circumstances, this shift seems to have increased poverty (Imai et al., 2014).

Theoretically, structural transformation in the economy is driving on-farm labor into the off-farm sector for pursing a more sustainable livelihood. Some farming households exit farm and move to other sectors, as they consider agriculture a low productive and highly risky occupation (Haggblade et al., 2010; Hussain, 2014). Farm exit to off-farm sectors has been extensively investigated (Kimhi and Bollman, 1999; Pietola et al., 2002; Glauben et al., 2006; World Bank, 2007; Cai and Wang, 2010; Knight et al., 2011; Wang et al., 2011; Bhandari, 2013; Ahmad et al., 2020). In contrast, the shift from off-farm to on-farm as new farm entry has not been investigated yet in the context of agricultural-based economies including Pakistan. In such cases, promoting agricultural activities remains a priority in order to achieve the Millennium Development Goal (MDG), which is to reduce poverty and hunger, to sustain livelihoods by increasing new and well educated farmers and by stop farm exits as well (World Bank, 2008). Adjustments to an agricultural structure could also attract and encourage more people to enter farming and pursue farming either as a main occupation or an additional source of income (Mishra and El-Osta, 2016). In addition, the emphasis of farmers' rights for self-sufficiency in food by growing their own food can encourage former farmers to return to farming (Agarwal and Agrawal, 2017).

Pakistan is heavily dependent on agricultural production which contributes 24% to its GDP (Pakistan Bureau of Statistics, 2019). Unfortunately, its agricultural system fails to maintain its growth due to serious challenges such as water shortage, climatic change, rising input prices, limited policy incentives for farming and low trust in government, making farmers reduce their cultivated area and worsen the country's overall agricultural productivity (Pakistan Bureau of Statistics, 2018). Following the 9/11 event in U.S. in 2001, Pakistan has fought a long war of 19 years against terrorism as an ally of the US, by closing doors to foreign investments. Since then, the farm sector has been in its recession. Pakistan's agriculture sector started to decrease in sizes since 2001 due to emerging water shortages, climatic changes and natural disastrous events (floods, heavy rain and drought), as well as high input prices, low output prices, which reduced the earnings of both farming and non-farming communities, and increased the unemployment rate in the country (State Bank of Pakistan, 2015). More importantly, the challenges mentioned above are causing farmers to exit from farming. For example, the agricultural sector has experienced an obvious decline at both the absolute and relative levels in farm employment percentage, from 45 to 38.5% over the last decade (Pakistan Bureau of Statistics, 2018). It is thus of importance to know why farmers exit agriculture and how their livelihoods change after exit (Ahmad et al., 2020).

This study aims to firstly close a significant research gap by identifying the factors driving farm entry and exit in Pakistan. Secondly, this study further investigates the impact of farm entry and exit on households' wellbeing in terms of total household income, food security status and ability to save for an emergency funds. Thirdly, this study also aims to identify the beginner farmers, who are they, and why did they enter into farming? To the best of our knowledge, these can be the first empirical work to examine both farm entry and exit decisions for rural households in Pakistan.

To achieve the goals above, this study is organized as follows: The next section provides a comprehensive literature review, followed by introducing farmers' livelihood options in Pakistan. Section 4 provides a conceptual framework, followed by introducing our methods and data. Section 6 provides estimated results and analyses, followed by a balance test and sensitive analyses. The last section concludes.

2 Literature review

Over the past century, agriculture sector has transformed from a labor-intensive to a capital-intensive industry. The shift has allowed people to engage in secondary and tertiary sectors and to relocate to non-farm regions. As a result, farming workers have fallen significantly (Lobao and Meyer, 2001; Gale 2003; Conkin, 2008; Ahearn and Newton, 2009). For example, Gale (2003) noted that most farm exits are voluntary, retiring, passing management to the next-generation or leaving farming due to poor health and death in western countries. The family farm is viewed as the backbone of rural communities and the decline of farm number raises questions with regard to whether these communities can sustain themselves. Although intergenerational family transfer remains the dominant mechanism for farm succession, in most western European countries and the United States, the number of family farm transfers was decreasing (Gale, 2003; Calus et al., 2008).

For the new entry farm, there could be some barriers for the new farmers. For example, the studies consistently identify access to affordable land as the greatest barrier to entry to agriculture (Ackoff et al., 2017; Frost, 2017). Many beginning farmers said that they lacked the means to employ the number of skilled farm workers necessary to maintain and grow farm operations (Ackoff et al., 2017). Climate change could be the key issue causing an increase in unpredictable extreme weather events; increases in drought and flooding events threaten to destroy crops and reduce yields and most of the farmers have experienced the influence of climate changes (Ackoff et al., 2017). Therefore, many small- and mid-size farm operators require off-farm income to make ends meet (Gillespie and Johnson, 2010). In general, beginning farmers face steep start-up costs and barriers to accessing capital, land, and credit (Ahearn, 2011; Lusher Shute, 2011; Calo, 2018).

Farming is characterized by an ageing population with a reduced rate of entry into farming by younger farmers and a reduced rate of retirement by older farmers (ADAS, 2004). The farming industry has failed to attract "new blood" into the industry, partly due to the poor rewards and partly due to entry barriers such as high start-up costs and a shortage of available land (ADAS, 2004); something that is exacerbated by restructuring processes that are leading to fewer, larger farms within both the private and county estates (Whitehead and Millard, 2000). At the same time, a lack of suitable successors and taxation issues have been identified as making farmers reluctant to retire (Williams and Farrington, 2006). This is the result of a number of entry-exit challenges such as increasing capital requirements, low expected rates of return and higher off-farm career opportunities (Gale, 2003; Williams and Farrington, 2006). Several studies from developed countries have highlighted these adjustment challenges facing the farming industry (Caskie et al., 2002; Errington and Lobley, 2002; ADAS, 2004; Calus et al., 2008).

Concerns about the sustainability of an ageing farming population have brought interest in so called entry-exit issues in policy circles. Policy interventions to date have offered limited scope in stimulating farm transfer, however, the increase in unconventional tenures which include partnerships, share farming and contract farming, would appear to offer new opportunities for those wishing to enter or leave farming (Ingram and Kirwan, 2011). Bruce (2019) identified a new pathway into alternative agriculture that returning farmers come from farm families, but left agriculture to pursue higher education or a non-farm career and then re-entered agriculture later in life through Alternative Food Networks (AFNs). However, social movements promoting alternative models of agriculture have created organizations to support a new generation of farmers, and generated AFNs that provide new training opportunities and markets for aspiring farmers.

3 Farmers' livelihood options in Pakistan

As most of agriculture farms in Pakistan are small and not well educated, thus they do not have better off-farm jobs in the country except daily paid labor. For example, a study from Khyber Pakhtunkhwa (KPK) province investigated the determinants of the off-farm employment of the small farm which showed that most of small farms (90%) were engaged in off-farm jobs along with agricultural activities (Ali et al., 2014). The nature of their job was in daily paid labor, part time employment, and different off-farm businesses. The effects of farm underemployment, working age group size (age of the farmer), income from other sources, and education were positive on the off-farm employment (Ali et al., 2014). For example, Rizwan et al. (2017) conducted a study in province Punjab, Pakistan and found that about 66% farmers were involved with off-farm activities along with on-farm activities. The results indicated that education has significant influence and stimulate for engagement in off-farm employment. However, presence of younger population in households and land renting opportunity stimulate migration in other cities and countries. Dependency ratio and large family size were the driving factors for participation in off-farm labour activities.

Though, off-farm activities as part-time are also being performed in Gilgit-Baltistan, Pakistan. In this case, farmer characteristics (e.g. farmer age, gender and education), farm characteristics (e.g., farm size, specialization in horticulture, etc.) and agricultural income (Shahzad et al., 2021). Tahir et al. (2012) investigated the factors contributing to off-farm employment in North West Pakistan. They found that farm size, family size, farm underemployment, education, and income from other sources were the main factors determining off-farm employment. It was also observed that farmers of the comparatively developed areas devote more time to off-farm employment. The study revealed that most of the farmers were engaged in daily paid labor. Overall there is a gradual shift from farm to off-farm employment which is resisted by the underdeveloped means of transport and communication, education and lack of basic infrastructure.

Few studies that investigated the factors that affect occupational choices of populations living in rural areas of Pakistan. Jan et al. (2012) revealed that the likelihood to participate in non-farm informal sector increases for household having relatively younger head with no education. Household size positively and significantly related to all the occupational groups while additional working members in a household reduces the odds to engage in farming by about 67% relative to non-farm informal sector. Similarly, *per capita* income also plays a significant role in pursuing occupations other than informal activities. In addition, to know the influence of migration on farm exit, Abbasi and Kim (2018) investigated that agriculture is not the primary source of income and 32%

agriculture labor force migrated and migration is the main reason for declining labor force and increasing shifted to off farm activities.

However, the youth (aged between 15 and 29 years) in Pakistan seems less interested in performing agriculture activities. They regarded the agriculture sector as non-profitable, hence they do not see them joining the agriculture sector due to high cost of production, crashed marketing system, absence of farmer-friendly policies, environmental issues and lack of support from government in agriculture sector (Ahmad et al., 2020; Aftab et al., 2021). Thus, most of farms are involved in non-farm income generation activities in southern Punjab, Pakistan. The majority of the farmers offered labor for off-farm work followed by self-employment ventures. The major reason to pursue non-farm work includes low income from agriculture, mitigating risks associated with farming. A range of socioeconomic and infrastructure-related variables are associated with the decision to participate in specific off-farm activity, such as age, education, family size, farm income, dependency burden, farming experience, and distance to the main city.

In case of Pakistan, there has been a steady shift from subsistence farming to cash crops and fruit production, which is particularly noticeable in the accessible parts of the region that are located closer to urban centers. In addition, the rising proportion of household income from non-farm activities (increasing from 43% in 1994 to 63% in 2005 and more than 70% in 2020 (Shahzad et al., 2021), plays an important role in the transformation of the rural economy. Similarly, the increased labor outmigration towards the services sector in down-country Pakistan stemming from the improved formal education systems has increased the share of non-farm employment plays an important role in the transformation of the rural economy. Similarly, the increased labor outmigration towards the services sector in down-country Pakistan stemming from the improved formal education systems has increased the share of non-farm employment.

Under these circumstances, the maintenance of farming communities is largely under threat. The increased rate of rural-to-urban migration (Gioli et al., 2014), particularly that of younger people (Benz, 2016) and the rapid growth of the non-farm sector (Gioli et al., 2014; Shahzad et al., 2021) have resulted in decreased agricultural land-use and increased uncertainty regarding farm continuation.

4 Conceptual framework

Studies on rural off-farm and on-farm activities consider livelihood diversification and income stabilization (or risk minimization) as the major motives for working outside of agriculture (Rose, 2001; Haggblade et al., 2010). Livelihood diversification is driven by "pull" factors (e.g., markets, opportunities, infrastructural facilities and supportive institutions) and "push" factors (e.g., various idiosyncratic shocks such as floods, droughts, environmental degradation, chronic rainfall deficit). Similarly, off-farm labor could shift towards farming activities in case of unemployment, old age, job insecurity and health issues (Mishra and El-Osta, 2016). Also, farmers' rights for self-sufficiency in food by growing their own food can encourage former farmers to return to farming (Agarwal and Agrawal, 2017). As a result, a large part of the world's labor force work in agriculture, not by choice, but due to lack of alternatives (Cain, 1977; Kumar and Hotchkiss, 1988; Chitrakar, 1990; Karan and Ishii, 1995; Filmer and Pritchett, 1997; Agarwal, 2014). It is important to understand households' motives of diversifying beyond agriculture or moving away from off-farm work. Therefore, we base our theoretical framework on livelihood vulnerability as diversification/transition motive, because it best serves the main objective of the study, which is to investigate the determinants of households' diversification decisions[1]of farm entry and exit.

To better understand the Pakistani agriculture sector, we classify the factors associated with "farm entry and exit" into the following groups: 1) human capital referring to characteristics of household head and household; 2) natural capital including land, livestock and irrigation systems; 3) economic capital comprising of loans or credit, off-farm employment, and off-farm income and sources; 4) climate shocks, including natural disasters and severe crop diseases; 5) climate change investment[2] referring to access to micro finance institutions (MFIs), all weather road and climate knowledge (Eifert and Ramachandran, 2004); and 6) locational characteristics such as home remoteness and the extent of commercialization and urbanization.

It is hypothesized that a household can involve in one of the two livelihood transition scenarios: 1) exit farming and shift to off-farm activities; or 2) enter farming and shift to on-farm activities. Each household is assumed to make a rational choice, which is when income generated from the new sector is higher than that from the last. Households that intends to enter farming face barrier such as capital investment, climate challenges, farming experience, knowledge and skills and other household constraints. Similarly, households that want to exit farming could face barriers in off-farm employment, age, skilled labor, education, family labor and other household constraints. We assume that a farming household i has fixed capital and labor

1 Even if the motive of the household is higher income, climate shocks affecting agricultural income may still influence its expected earnings, and hence the diversification decision.

2 Climate change investment is defined as different characteristics specific to a certain location that could act as incentives or disincentives for entry or exit such as availability/unavailability of financial services, infrastructure, governance and regulations etc. (Eifert and Ramachandran, 2004).

endowments, assigned among different activities in agriculture, which is expressed in Equation One:

$$I_i = E_t \sum_{\tau=1}^{T} \beta^{\tau-1} \pi_i \left(IP, OP, LC_i, \varphi_t, \varepsilon_i\right) \tag{1}$$

Where I_i is the income of household i, E_t is expectation operator providing information at time t, β is the subjective discount factor, T is the number of periods, π_i isthe profit generated for household i which is a function of input price IP, output price OP, fixed labor and capital endowments LC_i, a vector of economic shocks that could affect household income and livelihood diversification φ_t, and ε_i includes unobserved characteristics that could affect income. Suppose a household is generating income from agricultural activities, Equation One is adapted to Equation Two with subscript A indicating agriculture:

$$I_{Ai} = E_t \sum_{\tau=1}^{T} \beta^{\tau-1} \pi_{A,i} \left(IP_A, OP_A, LC_i, \varphi_t, \varepsilon_i\right) \tag{2}$$

For farm entry, household income is denoted by (I_{B_i}) and expressed in Equation Three:

$$I_{Bi} = -C_{i,t}\left(N_i,\ I_i,\ H_i,\right) + E_t \sum_{\tau=1}^{T} \beta^{\tau-1} \pi_{Bi}$$

$$\left(IP_B,\ (N_i,\ I_i), OP_B\left(N_i,\ I_i\right), LC_{B,i}, \mu_i\right) \tag{3}$$

Where $C_{i,t}$ is farm entry cost, which could be affected by investment I_i such as climate, capital and farm machinery assets and other inputs. Furthermore, other factors like availability of financial services, government policies, taxes and infrastructure could reduce or increase the entrance barrier. These characteristics could also capture input-output markets at specific locations and availability of micro finance institutions (MFIs) and farm advisory services. Furthermore, farm entry could also be affected by the characteristics of household head (H_i) such as age, education, migration status and location (N_i). Input prices (IP_B) and output prices (OP_B) are part of the entry function into farming, which could be affected by location factors that may be associated with lower than market prices for crop outputs[3] and μ_i isunobserved characteristics.

Households assign their total amount of fixed labor and capital for different activities, which can be expressed as:

$$LC_i = LC_{A_i} + LC_{B_i} \tag{4}$$

As we mentioned above, household could diversify income strategy through farm entry if on-farm income is greater than off-farm income, as shown in Eq. 6.

$$I_{A_i} + I_{B_i} > I_i \tag{5}$$

OR

$$I_{B_i} > I_i - I_{A_i} \tag{6}$$

Following Eq. 6, the probability of diversifying to farming can be written as:

$$prob_{(B_i)} = prob\left(-C_{i_t}\left(N_i,\ I_i,\ H_i,\right) + E_t \sum_{\tau=1}^{T} \beta^{\tau-1} \pi_{Bi}\left(IP_B, (N_i,\ I_i),\right.\right.$$

$$OP_B\left(N_i,\ I_i\right), LC_{B_i}, \mu_i)) > prob\left(E_t \sum_{\tau=1}^{T} \beta^{\tau-1} \pi_i\right.$$

$$\left.\left.\left(IP, OP, LC_i, \varphi_t, \varepsilon_i\right) - \pi_{Ai}\left(IP_A, OP_B, LC_i, \varphi_t, \varepsilon_i\right)\right)\right) \tag{7}$$

As input and output prices do not change whether the household works only in agriculture or diversity to off-farm work. Therefore, we do not expect them to play a significant role in affecting household's choice except when the actual level of profit is estimated. Hence, we expect that household labor and capital endowments, which are fixed, may play a vital role in decisions on farm entry and exit.

If a household enters into farming, d_{B_i} is defined as 1, and 0 if a household stays in off-farm activities (see Supplementary Appendix SA1). Stochastic factors ε_i and μ_i are assumed to be identically and independently distributed, and then the probability of farm entry is given as:

$$\begin{cases} f\left(H_i, N_i, I_i, \varphi_t\right) & if\ d_{B_i} = 1 \\ 0 & otherwise \end{cases} \tag{8}$$

Further, once households enter into farming, they could face two choices: either continue or exit farming. Households could face barriers when existing farming, such as investment made on non-transferable fixed assets, land rent, farm machinery and long run investment. Whereas, incentives at household level such as high grain prices could encourage farm entry, particularly for those who enter to produce domestic grain food. The income generated from agriculture will then depend on the trade-off between the cost of farm exit and the profit earned from continuing farming. Moreover, households' earnings depend upon farming inputs and output prices which are determinants of farm entry together with other factors such as land status, yields, etc. Given these, if the present value of on-farm income is less than off-farm income, household will decide to exit farming, which can be expressed as:

$$I_{B_i}^{E} < I_i^{E} - I_{A_i}^{E} \tag{9}$$

where I_i^E is income of an incumbent household i. Likewise, the probability of farm exit is a function of household specific characteristics H_i, farming capital factors FC_i, fixed inputs of labor and capital LC_i, locational specific factors (N_i, I_i) and climate shocks affecting agriculture (φ_i).

3 Firstly, most of the farms in Pakistan are small and did not have access to commercial markets. Therefore, they are dealt by commission agents or middle men and they are offered a low price for their output. Secondly, farmers who use crop inputs on credit incur a heavy markup and are bounded to sell their crop outputs to input dealers or lenders at a low price.

TABLE 1 Study provinces and sample size.

Province	Number of districts	Exit farming	Continue farming	Stay off-farm	Enter into farming	Total sample
Punjab	12	62	460	533	131	1,186
Sindh	5	60	216	136	60	472
KPK	2	14	113	47	35	209
Total	**19**	**136**	**789**	**716**	**226**	**1867**

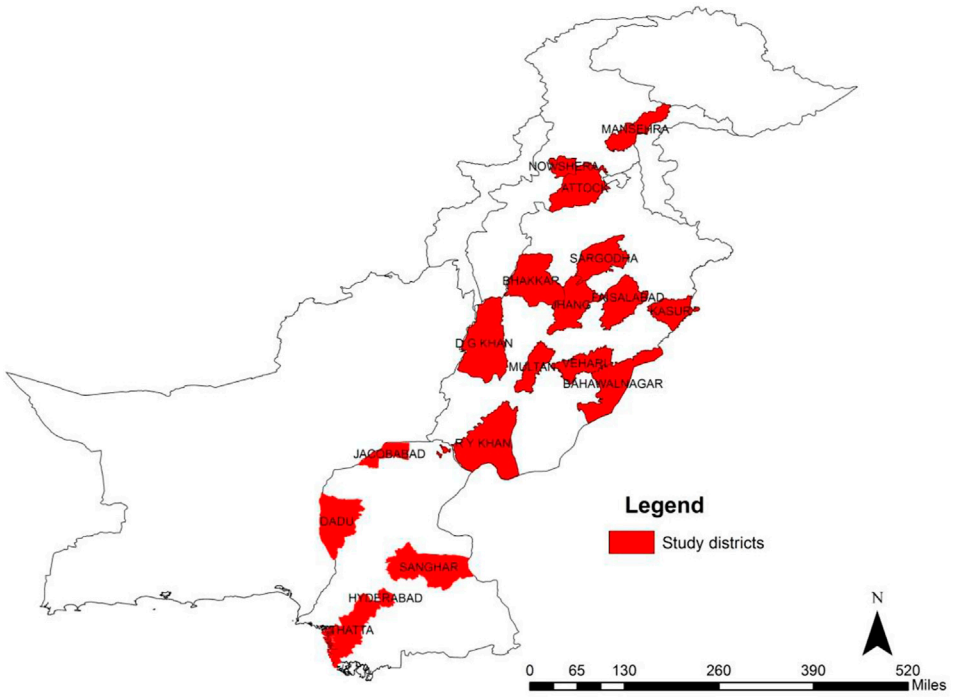

FIGURE 1
Study districts and map of Pakistan.

5 Methods and data

5.1 The data

Data for this study is derived from the Pakistan Rural Household Panel survey conducted in the Punjab, Sindh and Khyber-Pakhtunkhwa (KPK) provinces of Pakistan in 2012–2014.

The survey was designed and supervised by International Food Policy Research Institute (IFPRI) and was administered by Innovative Development Strategies (IDS), Islamabad, Pakistan. IDS served as the data collector and handled all of the survey logistics, from enumerator training to the processing of the completed questionnaires. This panel survey contains three different rounds: Rounds 1, Round 1.5, and Round 2, which identifies the status of household either continue or exit farming and their climate change adaptation measure at farm level (International Food Policy Research Institute, 2014; International Food Policy Research Institute, 2015; International Food Policy Research Institute, 2016; International Food Policy Research Institute, 2017). Additionally, one of author personally took part in data collection when surveys were conducted in 2012 and 2014 in all three rounds.

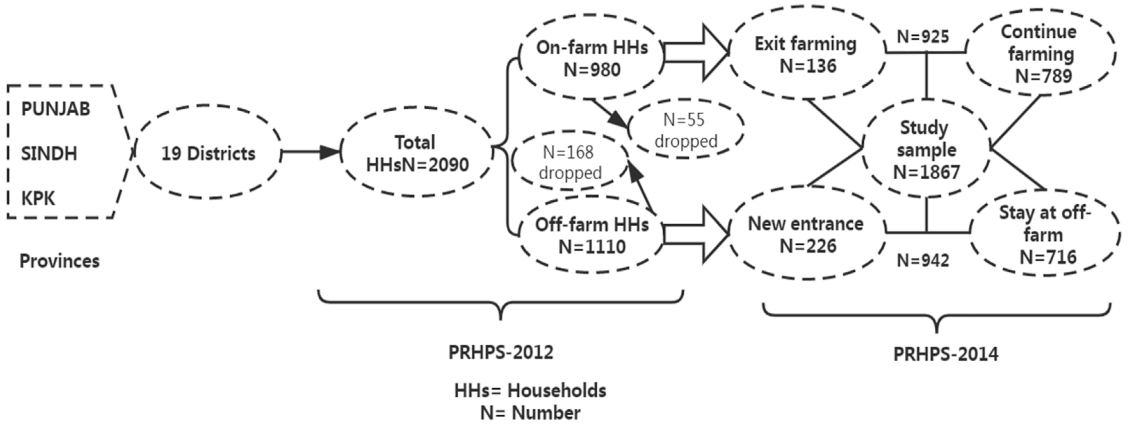

FIGURE 2
Sampling of Households (HHs) and study process from the Pakistan Rural Household Panel Survey (PRHPS, 2012–2014).

A total of 19 districts were surveyed across three provinces: 12 from Punjab, 5 from Sindh and 2 from KPK (Table 1; Figures 1,2[4]). Within each district, 4 mouzas[5] were chosen as Primary Sampling Units (PSU) using an equal probability systematic selection approach. The lists of revenue villages/mouzas/dehs provided by the 1998 Population Census were used as the sampling frame. The enumeration teams sectioned each mouza into enumeration blocks according to the village map. Each block consists of a maximum of 200 households. Subsequently, one enumeration block was randomly chosen from each mouza and households within a PSU were considered as Secondary Sampling Units (SSU). Then 28 households were randomly selected from each block of a maximum of 200 households. Finally, households (HHs) were defined as, 'a family or group of persons living in common accommodation (family members living in the same building or boundary wall), and cooking or sharing all their meals together'. The respondents were the most knowledgeable member and major decision maker in domestic affairs within the household.

The survey includes various types of information on human capital, natural capital, economic capital, locational characteristics, as well as household demographic and socioeconomic characteristics. We utilize the surveyed household panel dataset (2012–2014) to identify farm entry and exit of rural households as a whole. The first round survey in 2012 includes additional household information for the year 2010 and 2011. For example, the 2012 survey contains information on employment of the households such as whether they were working on-farm[6] (farmer) or off-farm[7] (not a farmer) in year 2010 and 2011 as well as in 2012, respectively. The 2014 survey asked the same question for 2012, 2013 and 2014.

Out of the total 2090 surveyed households, 1,110 (53%) were working off-farm, while the remaining 980 (47%) were working on-farm in 2012. We then matched these1110[8] households with those in the 2014 survey to identify any "new entrant"[9] into farming. It is found that 226 (24%) off-farm households in 2012 entered farming in 2014 and were defined as "new entrants" (see Table 1; Figures 2, 3). We matched 980[10] households with the 2014 survey to identify any "farm exit". It is found that 136 (15%) households exited farming in 2014, and were defined as "exit farming" (Figure 4).

4 Baluchistan province was not surveyed and skipped due to security reasons. The sample excludes rural areas in Baluchistan and the Federally Administered Tribal Areas because they were considered unsafe for the enumeration.

5 In Pakistan, province subunit is district, then district subunit is Tehsil, whereas Tehsil subunit is Union Council, and Union Council subunit is Mouza, and Mouza subunit is village/dehs, village/dehs subunit is Basti/Chak (groups of several households/families lived in and are identified by their Basti/Chak).

6 Household head/individual(s) from a family who cultivated farmland, despite the fact that any of family member worked at off–farm are considered as on–farm households.

7 Household head individual(s) from a household/family who did not cultivate farmland since 2010–2014 are considered as off–farm households.

8 From 1,110 households, 168 observations were dropped due to missing data and therefore 942 households remained in 2014.

9 "New entrants" into farming referred to households who did not cultivate land and were working off–farm since 2010 but started agricultural activities for the first time in 2014. Moreover, inheriting a family farm is also considered as "new entrant".

10 55 observations were dropped due to missing data and therefore 925 households remained in 2014.

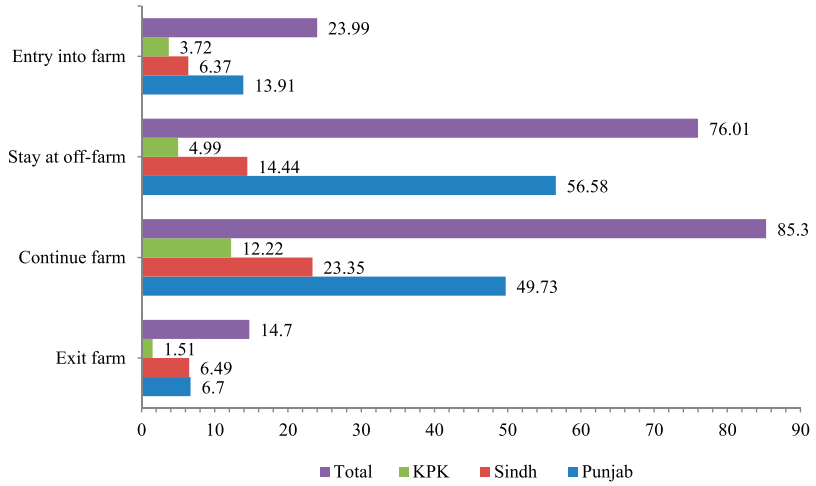

FIGURE 3
Household statuses based on entering and stay at off–farm and exiting and continuing farming.

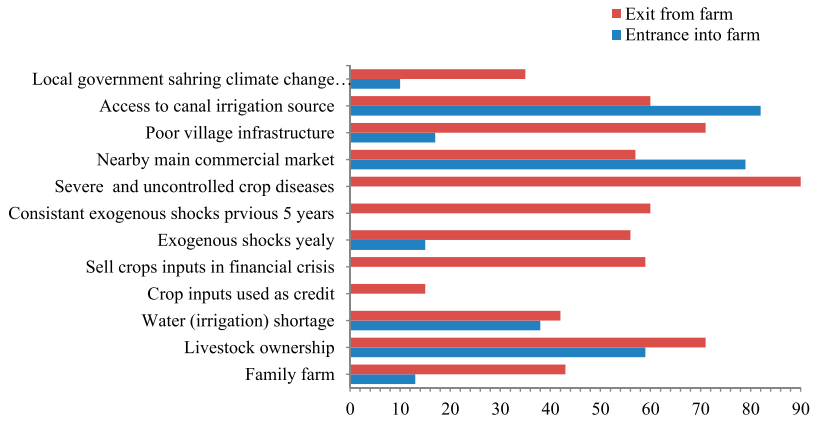

FIGURE 4
Perceived main factors for entrance and exit into and from farming (percentage of households who responded accordingly.

In addition, we tested for multicollinearity among the explanatory variables using the Variance Inflation Factor (VIF). If the maximum VIF value is above 10, there will be econometrically problematic (Wooldridge, 2009; Bai et al., 2010). In our test, the VIF is below 3.5 and therefore there is not found multicollinearity.

5.2 Econometric approach

We used Probit model due to the dichotomous nature of both dependent variables—farm exit and farm entry, whose estimation equations are expressed in Eqs 10, 11, respectively.

$$prob_{(exit)} = \gamma_1 HH_i + \gamma_2 HC_i + \gamma_3 LC_{i+}\gamma_4 NC_i + \gamma_5 EC_i + \gamma_6 ES_i + \gamma_7 CI_i + \gamma_8 LC_i + \gamma_9 \varphi_t + \xi \quad (10)$$

$$prob_{(entry)} = \theta_1 HH_i + \theta_2 HC_i + \theta_3 LC_i + \theta_4 NC_i + \theta_5 EC_i + \theta_6 ES_i + \theta_7 CI_i + \theta_8 LC_i + \theta_9 \varphi_t + \nu \quad (11)$$

Where HH_i is the indicator of household head characteristics such as age, education and status of immigration, HC_i is household characteristics such as fixed inputs of labor and capital and household size. Household wealth is measured by building material of house (concrete or mud) and grain shortage in the last

year. NC_i indicates natural capital (e.g., land ownership, access to canal irrigation, water shortage, water availability for irrigation in Rabi and Kharif seasons[11], actively working Khal Panchayats system[12]and livestock ownership). EC_i indicates economic capital (e.g., owned and run off-farm business, off-farm income, outstanding loans, crop inputs used as credit and for sale in financial crisis). We also estimated total household non-agricultural income (e.g., government transfers, remittances, salaries from off-farm employment, wages, insurance and pensions). ES_i indicates climate shocks (e.g. abnormal temperature, droughts, crop diseases, rainfall and floods). CI_i indicates climate change investment (e.g., distance from MFIs, climate relevant knowledge provided by local government, and access to commercial markets and all-weather road). LC_i indicates locational characteristics (e.g., access to nearby city and to commercial markets, distance to off-farm source (factory/industries) and district, access means to main commercial market, and quality of village infrastructure) (Refer to Supplementary Appendix SA1). γ s and θ s are the corresponding vectors of parameters to be estimated, ξ and ν are the error terms.

5.3 Impact of entry and exit on household wellbeing

We measured wellbeing of a household by three major indicators: total household income, index of food security status, and ability of saving for an emergency fund. We constructed an index of food security status for the year 2012, based on the PRHPS survey that collected information on households' experience of food shortage caused by various climate shocks and illness or death of household member(s) between 2012 and 2014. The index ranges from zero to three, zero being no food shortage and three being the highest level of food shortage. Households' ability of saving for an emergency fund was coded as "1" when they are able to raise Rs.2000[13] during an emergency and "0" otherwise.

11 Pakistan has two major crop seasons: Kharif (broadly July to October) and Rabi (broadly October to March/April).

12 Khal Panchayats or water users' associations are mandated to mediate water distribution conflicts, maintain watercourses, report on tampering of outlets and shortage of water supply in the outlet to minor or distributary–level farmer organizations, collect water charges, and provide timely information about rotational running of channels to the farmers.

13 Rs.2000/day or ($22/day) earning is a reasonable amount for households to survive particularly in case of emergency such as floods, droughts or any disaster occurring in the community.

5.4 Propensity score matching

To evaluate the impact of farm exit and new entrance, we apply the propensity score matching (PSM) method to control for selection bias. An evaluation that failed to control for such selection bias would conflate the effects of farm exit and new entrance on outcomes with the effects of pre-existing differences between farm exit and new entrance. When applying the PSM method, we also test the sensitivity of estimates to potential hidden biases. In theory, the impacts of a farm exit and new entrance should be evaluated by estimating the average treatment effect on the treated (ATT). Thus, we employed PSM to address any self-selection bias of household in their entry/exit decision, because the model matches households that share the same pre-treatment observed socioeconomic characteristics (Heckman et al., 1997; Ali and Peerlings, 2012).

Let $D_i \in \{1, 0\}$ be an indicator whether a household i has received a treatment or not. The propensity score $P(X)$ is defined as the conditional probability of receiving a treatment given pre-treatment characteristics as:

$$P(X) \equiv prob(D_i = |X) = E(D_i|X) \tag{12}$$

where X denotes a vector of pre-treatment characteristics and E is the expectation operator. The propensity score can be predicted with either a logit model under the assumption of a normal or logistic cumulative distribution, respectively. Once the propensity scores are generated, the treatment effect can then be calculated by selecting households that are "nearest neighbor 1-to-1 matching method with replacement" in terms of their estimated propensity scores. The most common estimate of treatment effects in the evaluation literature is the average treatment effect on the treated (ATT). If the potential outcome of the treatment, which is defined as household wellbeing previously, is denoted by $Y_i(D_i)$, then the average treatment effect (ATT) is given as:

$$ATT = E(T|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \tag{13}$$

Where $E(Y_1 D = 1)$ is the expected outcome for those households that have actually received a treatment, in this case those that have entered into or exited from farming, and $E(Y_0|D = 1)$ is the counterfactual for the treated, which estimates what the outcome would be if those households that have in fact received a treatment do not do so. An important assumption of PSM is the Conditional Independence Assumption (CIA), which states that the set of pre-treatment observable characteristics that are included in the matching should determine both the probability of receiving a treatment (entering into and exiting from farming) and the outcome of interest (household wellbeing); that is $(Y_0, Y_1) \perp D|X$, denoting the statistical independence of (Y_0, Y_1), conditional on pre-treatment observable characteristics X (Heckman et al., 1997). Given that the CIA holds, the PSM estimate for the ATT can be written as:

$$ATT_{PSM} = EP_{(X|D=1)}\{E[Y_1|D = 1, P(X)] - [Y_0|D = 1, P(X)]\} \tag{14}$$

TABLE 2 Descriptive analysis and household characteristics comparison (mean and percentage).

Livelihood assets	New entrance (*N* = 226)	Stay at off farm (*N* = 716)	Left farming (*N* = 136)	Continue farming (*N* = 789)
Household head characteristics				
Age (years)	46.42	46.15	44.26**	47.03
Education (years)	3.72	3.56	3.99	3.49
Immigrant (Yes = 1)	0.04	0.04	0.14**	0.07
Household characteristics				
Family size (No.)	6.26	6.18	6.09***	6.84
Number of working age individuals (16–64 years)	2.60	2.38	2.44	2.79
Number of working age children (6–15 years)	1.49*	1.46	1.43**	1.55
Number of elderly persons (>64 years)	0.26	0.20	0.13***	0.28
Pucca (concrete) house (Yes = 1)	0.06*	0.03	0.01**	0.05
HHs faced shortage of grain food during a year (Yes = 1)	0.27*	0.21	0.31***	0.15
Natural capital				
Own land (Yes = 1)	0.13*	0.05	0.43***	0.77
Livestock ownership (Yes = 1)	0.59**	0.50	0.71***	0.87
Canal irrigation (Yes = 1)	0.82***	0.70	0.60***	0.74
Water (irrigation) shortage during the year (Yes = 1)	0.38***	0.52	0.42	0.44
Khal Panchayats system exists (Yes = 1)	0.07***	0.15	—	—
Khal Panchayats system actively work (Yes = 1)	0.15***	0.05	—	—
Water availability in Rabi season (No. of weeks)	—	—	9.49**	11.18
Water availability in Kharif season (No. of weeks)	—	—	10.61***	13.27
Economic capital				
Household owned off-farm business (Yes = 1)	0.15	0.15	0.40	0.37
Household Off-farm income (>Rs. 300 k = 1)	0.27	0.23	0.02	0.01
Household total income (Rs.)	213,792	258,086.3	273,426.5	381,160.6
Outstanding loans (Yes = 1)	0.07**	0.12	0.12*	0.10
Crop inputs used as credit and paid markup (Yes = 1)	—	—	0.15*	0.11
Households sell crops inputs in financial crisis (Yes = 1)	—	—	0.59*	0.32
Climate shocks				
Household affected by natural disasters every year (Yes = 1)	0.15	0.05	0.56***	0.33
Household farms affected by natural disaster shocks for last 5 years (Yes = 1)	—	—	0.60***	0.37
Household farms affected by uncontrolled crop diseases (Yes = 1)	—	—	0.90**	0.68
Climate investment				
Distance to nearest from MFIs (Km)	19.93	18.75	14.27***	17.87
Access to nearest all-weather road (Mins)	49.42	55.22	52.69***	40.85
Local government helping in sharing climate change knowledge (Yes = 1)	0.10	0.27	0.35*	0.02
Locational characteristics				
Nearby city travelling time (minutes)	33.52	35.76	43.74***	33.78
Nearby small commercial market distance (km)	15.05	16.14	20.55**	16.66
Distance to district headquarter (km)	49.20***	43.34	33.76***	42.05
Nearby main commercial market (Pacca_road = 1)	0.79	0.78	0.57	0.61
Poor village infrastructure (kacha road = 1)	0.17	0.17	0.71	0.70
Entry and Exit decisions across provinces				
Punjab	0.14	0.57	0.07	0.50
Sindh	0.06	0.14	0.06	0.23
KPK	0.04	0.05	0.02	0.14
Overall	0.24	0.76	0.15	0.85

Notes: The significance differences between entrance and stay at off-farm, continuing and exiting farming were tested using a one-way ANOVA F-test or a chi-square as appropriate. ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

To eliminate outliers that have very high and very low propensity scores, the matching should be restricted to the area of the common support in the sample, which can be done by dropping the treatment observations at which the propensity score density of the control observation is the lowest (Sianesi, 2004). To be effective, matching should also balance explanatory variables across the treated and non-treated groups. A balancing test performed after the match can check the quality of the match by assessing the extent to which differences in explanatory characteristics between the treated and non-treated groups have been eliminated.

6 Results and analyses

6.1 Descriptive statistics

Table 2 that the age of household heads exiting farming (44) is significantly less than that of those staying farming (47). Household migration status contributes significantly to farm exit (14% vs. 7%), but insignificantly to farm entry. Households that have more family members aged 6 to 15 are significantly more likely to enter farming (1.49 vs. 1.46) and exit farming (1.43 vs. 1.55). This implies that family laborers, particularly working-age youths and adults might prefer to seek off-farm jobs. Similarly, those living in a pucca or concrete house are significantly more likely to enter farming and staying at off-farm (6% vs. 3%), as well to continue and exit farming (5% vs. 1%). The proportion of households who faced a grain food shortage during a year has a significant influence on the decision to enter into farming (27% vs. 21%) and exit from farming (31% vs. 15%). Having a family farm or land ownership, is significantly more important for entry decisions, and less important when it comes to exit decisions (13% vs. 43%), respectively. This result is surprising for exiting households with land ownership (family farm), and raises a question about future of family farm in the country. However, in case of farm exit despite land ownership the reasons may be unavailability of successors within family or such farmers faced consistent crop losses due to climate shocks and severe crop diseases, lower output prices, and higher input prices, and therefore they might decide to rent out their land and shift to off-farm activates. Furthermore, the results depict that livestock ownership is also contributing significantly for both entry and exit decisions (59% vs. 71%), respectively. Note that new entrant and households working off-farm may still own livestock by sharing with friends/relatives or landlords and animal feed is provided by owners of fodder, which is a common practice in rural Pakistan. Alternatively, women may take responsibility for the rearing of animals in rural Pakistan, and undertake field work such as crop sowing, harvesting, and bring herbs and grass as fodder for the animals (Ahmad and Ma, 2020b). Access to irrigation canal and Khal Panchayat system plays a significant role in entry decisions, whereas water shortage during crop seasons play a significant role in exit decisions. Economic capital in terms of outstanding loan, crop inputs used as credit and sold by farmers on net cash in financial crisis significantly increase farm exit (Ahmad and Ma, 2020b).

Turning to climate shocks, crops affected by natural disasters and severe crop diseases play a significant role in exit decisions. Furthermore, climate investments - the distance to MFIs and all-weather roads—play a significant role in exit farming.

For locational characteristics, distances from off-farm source location and home district are significantly contributing to both entry and exit decisions. Additionally, travelling time to nearby city and distance to commercial markets also significantly contribute to farm entry and exit.

6.2 Household head characteristics

The Probit models were then used to estimate the probability of farm entry and farm exit, respectively. Table 3 presents the marginal effects from the probit regression for decisions on farm entry and exit. In the exit model, migration status plays a significant role. Age makes a significant difference when it comes to farm entry, particularly in developed countries where farmers' retirement plans involve the recruitment of new and younger farmers (Kimhi and Bollman, 1999; Pietola et al., 2002; Vare and Heshmati, 2004; Glauben et al., 2006). Our results suggest that as the age of the household head increases, households are more likely to enter into farming. But age is insignificant in the exit model. This result seems plausible as the elderly may move to the farming sector when they become less productive with off-farm work due to aging and declined health conditions.

6.3 Household characteristics

In the entry model, larger households are less likely to enter into farming, mainly because such households have "surplus" labor to generate sufficient off-farm income. It also found that the households having more members in working age (16–64) are more likely to enter into farming. This result suggests that the presence of more adults overcome labor constraints and provide more hands in fertilizing the crops, weeding, taking out infested plants, and transplanting and harvesting. This result partly supports Ahmad et al. (2020) who found that the significant and positive relationship between working-age family member and farm exit. Surprisingly, households experiencing food shortage were more likely to exit from farming, which raises a serious concern in relation to why they faced food shortage despite growing their own grain. This seems to be contradictory to the approach of the Millennium Development Goal (MDG) that prioritizes farm activities as a means to reduce poverty and hunger (World Bank, 2008). Possibly this is because these households had to sell all their grain output to repay the previous loans or experienced severe crop losses due to climate shocks (Ahmad and Ma, 2020a).

TABLE 3 Marginal effects of probit regression for the probability of entrance and exit into and from farming.

Livelihood assets	Probability of entrance	Probability of exit
Household head characteristics		
Age (years)	0.002* (0.001)	0.001 (0.001)
Education (years)	0.002 (0.003)	0.002 (0.002)
Immigrant (Yes = 1)	−0.101 (0.068)	0.075* (0.039)
Household characteristics		
Family size (No.)	−0.019* (0.009)	-0.012 (0.008)
Number of working age individuals (16–64 years)	0.033** (0.013)	0.006 (0.011)
Number of working age children (6–15 years)	0.020 (0.014)	0.002 (0.012)
Number of elderly persons (>64 years)	0.045 (0.028)	−0.032 (0.024)
Pucca (concrete) house (Yes = 1)	0.122* (0.067)	−0.134* (0.074)
Household faced shortage of grain food during a year (Yes = 1)	−0.008 (0.059)	0.055** (0.025)
Natural capital		
Own land (Yes = 1)	0.409*** (0.081)	−0.136*** (0.022)
Livestock ownership (Yes = 1)	0.049* (0.026)	−0.074*** (0.025)
Canal water irrigation (Yes = 1)	0.272*** (0.042)	−0.190*** (0.017)
Water shortage during seasons (Yes = 1)	-0.146*** (0.030)	0.146*** (0.043)
Khal Panchayats system exists (Yes = 1)	-0.135*** (0.046)	—
Khal Panchayats system work actively (Yes = 1)	0.134*** (0.050)	—
Water availability in Rabi season (No.of weeks)	—	0.004* (0.002)
Water availability in Kharif season (No.of weeks)	—	−0.006** (0.002)
Economic capital		
Household owned off-farm business (Yes = 1)	−.015 (0.036)	−0.027 (0.043)
Household Off-farm income (>Rs. 300 k = 1)	0.001 (0.034)	0.172** (0.078)
Outstanding loans (Yes = 1)	−0.094* (0.044)	0.017 (0.032)
Households sell crops inputs in financial crisis (Yes = 1)	—	0.353*** (0.023)
Crop inputs used as credit (Yes = 1)	—	0.113*** (0.028)
Climate shocks		
Household affected by natural disasters every year (Yes = 1)	−0.138*** (0.044)	0.092* (0.050)
Household farms affected by natural disaster shocks for last 5 years (Yes = 1)	—	0.094* (0.049)
Household farms affected by uncontrolled crop diseases (Yes = 1)	—	0.148*** (0.034)
Climate investment		
Distance to nearest from MFIs (Km)	0.0003 (0.002)	−0.007*** (0.002)
Access to nearest all-weather road (Minutes)	−0.0003 (0.001)	−0.002** (0.001)
Local government sharing well climate change knowledge (Yes = 1)	—	−0.085* (0.092)
Locational characteristics		
Nearby city travelling time (minutes)	−0.001 (0.001)	0.003*** (0.001)
Nearby small commercial market distance (Km)	0.002 (0.002)	0.004*** (0.001)
Off-farm source (factory/ industries) distance from village less than 20 km = 1)	0.002 (0.002)	0.061** (0.028)
Distance to district headquarter (km)	−0.001 (0.001)	−0.001 (0.001)
Nearby main commercial market distance (Pacca_road = 1)	0.037 (0.037)	−0.104*** (0.027)
Poor village infrastructure (kacha road = 1)	—	−0.093*** (0.026)
Number of observations	942	925
Chi squared	213***	264.49***
Pseudo R^2	0.205	0.3424
Log likelihood	−412.55	−253.95

Notes: Robust standard errors are reported in parenthesis. ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

6.4 Natural capital

Access to capital as land ownership (family farm) increases the probability of farm entry by 40%, and reduces the probability of farm exit by 13%. Land ownership (family farms) are the most common business model in small-scale agriculture (Davidova and Thomson, 2013). Consequently, land ownership plays an important role in farming decisions. For example, in the case of access to credit or agricultural loans, only landowners can benefit from these services by using land as collateral. Households who owned land (family farm) and access to canal source irrigation were less likely to exit from farming with probabilities of 13% and 19%, respectively. As it may be the reason that family farms and water availability make farmers stay farming without extra cost of purchasing or hiring land and pumping groundwater for irrigation.

Livestock ownership encourages households to stay farming or enter into farming (as mixed-crop livestock production system). Ownership of livestock increases and reduces the probability of farm entry and farm exit by 5% and 7%, respectively. Mixed-crop livestock production is an integral part of farming all over the world including Pakistan, and is closely linked to livelihood strategies as a major source of food and income (Gurung, 1987; Herrero et al., 2010; Ahmad and Ma, 2020b). Households that own livestock (such as buffalo, cattle, sheep, and goats etc.) were significantly more likely to enter into farming and significantly less likely to exit farming. In fact, approximately 35%–40% of the

Pakistani population are dependent on livestock as their main source of income and the livestock sector provides food for over 8 million rural families (Pakistan Bureau of Statistics, 2019).

Households who have less access to water in Rabi crop season were more likely to exit farming compared with Kharif season. This is because most of the farms have enough canal irrigation in Kharif season while have limited water availability in Rabi season. Hence households exited farming due to irrigation water shortage in Kharif season. In contrast, households that have better access to canal source[14] of irrigation were more likely to enter farming, with an increase in the probability by 27%, less likely to exit farming, with a decrease in the probability by 19%. Farmers seem to prioritize the use of canal water, as it is the cheapest source of irrigation and it could also encourage farmers to enter farming. Furthermore, we found that where the Khal Panchayats system was working actively, farmers were more likely to enter into farming, increasing the probability by 13%. Due to shortage of water during the crop seasons, it reduces and increases the probability of entrance and exit decision by 14% and 15%, respectively. Additionally, our results in the exit model demonstrate the importance of irrigation across seasons.

6.5 Economic capital

As annual income generated from off-farm activities increases (more than Rs. 300 k), it also increases the probability of farm exit by 17%. Thus, household who worked at both on-farm and off-farm can compare both income and decide either to stay or exit farming. Hence, those who left farming, might find farming as a less rewarded occupation and eventually they could decide to exit farming due to higher off-farm income. However, in the entrance model, influence of off-farm income is positive but insignificant.

Financial constraints, especially those related to the use of crop inputs (rising prices of fertilizers, seed, pesticides, diesel for pumping ground water, etc.), seem to have serious effects on farmers and encourage them to exit farming in Pakistan. In this case, farmers experience large mark-ups on these input costs when they use them on credit, making them have no option but utilise their own income and limited (or non-existent) savings. As a result, outstanding loans create additional pressure for farmers, which affect their farming and even sometimes lead farmers to committing suicide (Mishra, 2006; Gruère and Sengupta, 2011). Our results show that farming households that use crop input as credits are more likely to exit farming, which increases the probability by 11%. Indeed, our results show that outstanding loans or debts can significantly increase the probability of farm exit. Meanwhile, longstanding loan and debt pressure could distress farmers and make them dislike or exit farming (Deshpande and Prabhu, 2005). Thus, as expected any mark-up imposed on using crop inputs (fertilizer, pesticide, seeds, etc.) as credit could push farmers to exit from farming due to financial constraints.

Our results also suggest that farm households who sold their crop inputs in financial crisis to feed families, were more likely to exit from farming, by a probability of 35%, which is higher than the effect of any other factors in this study. Approximate 60% of households have exited farming activities between 2012 and 2014, with one of the most important reasons being that farmers sold their borrowed or credit crops inputs (mainly fertilizer) in financial crisis (Ahmad and Ma, 2020b). For example, farmers first borrowed or credited crop inputs from input dealers at huge mark-ups, and then, they sold those crop inputs to neighbour farmers (someone else) or other input dealers on net cash at lower than market prices to deal with an emergency and feed families in financial crises. As a result, this behaviour not only increased the burden of loans on farmers but also converted their previous input-driven small loans into larger loans, if they fail to pay when the harvest was completed. To conclude, farmers should not depend only on on-farm income, and they should be involved with part time off-farm work to stabilize income and support their families in case of financial crisis particularly during the crop growing stages. As the crop input mark-ups are higher, first, farmers should avoid using these crop inputs on credit, and second should also avoid selling heavy mark-up crop inputs during an emergency, because this will create extra burden and lead to farm exit in the end. In addition, this behaviour could also discourage farm entry.

6.6 Climate shocks

Erratic climate is severely affecting the livelihoods of households who depend upon agricultural production. The results show that climate weather shocks not only affect farm exit but also have negative impact on farm entry. In fact, households who live in disasters prone regions were less likely to enter farming, with the probability being lowered by 14%. Similarly, households who faced climate shocks during last consecutive five years and were affected by severe crop disease were more likely to exit farming, with the probabilities of farm exit being increased by 9% and 15%, respectively.

To conclude, households that have experienced large crop losses due to heavy rain-fall, floods, droughts and severe crop disease are more likely to exit from farming, and these climate shocks push households to diversify their livelihoods beyond agriculture. As a result, the productivity of the agricultural sector decreased gradually due to emerging high input prices, lower output prices, water shortages, and climate shocks. However, those living in these regions face a number of challenges, such as food insecurity and poverty, driven in part by climate shocks, which encourage them to seek alternatives to farming and diversify their livelihoods towards off-farm activities (Glauben et al., 2006; Bhandari, 2013). Thus, climate shocks make farming livelihood more vulnerable and increases the likelihood to diversification. This finding is consistent with those of other studies in Pakistan on climate

14 In Pakistan, the availability of canal water supply is inconsistent (only 4–6 months in a year).

change and climate shocks and their effects on survival of livelihoods (Ahmad et al., 2020; Ahmad and Ma, 2020b).

6.7 Climate change investment

We found significant effects for distance to nearest MFIs, access to nearest all-weather road and the role of local government in farmers' wellbeing (only in exit model). The availability of MFIs in nearby locations has no significant effect on the entry decision. This may be because the poor access to MFIs reduces the required capital to start farming, and enables households to use their capital endowment for investment without necessarily being credit constrained (Huang et al., 2008; Ruan and Zhang, 2009; Ali et al., 2010). For example, those who have access to agricultural loans are more likely to continue farming while access to agricultural loans acts as an incentive for new entrants into farming. It appears that rural finance is important to farmers and therefore policymakers should consider policies to resolve such financial constraints to attract new farmers. In fact, the role of local government, particularly knowledge sharing of climate change and livelihood diversification, could significantly reduce the probability of farm exit by 8%.

6.8 Locational characteristics

The results show that the nearby city travelling time, distance to nearby small commercial markets, distance to nearby off-farm source (factory/industries), distance to main commercial markets, poor village infrastructure are all found significant in exiting from farming except for the distance to district headquarter. These results suggest that rural finance and urban employment could create significant and positive associations on entry into farming for all those who want to continue farming, or who are thinking of becoming farmers. Households that live within additional community service areas have a better chance of engaging in off-farm opportunities, which could induce them to start off-farm work. The distance to nearby off-farm sources (factories, mills, and industry) has a positive and significant association on farm exit. On the other hand, the distance to a nearby small commercial market has a positive and significant association on farm exit, but an insignificant association on farm entry.

6.9 Farm entry-exit decisions and household wellbeing

There are different matching methods to calculate the average treatment effects in the evaluation literature. The one we used in this study is before and after the nearest neighbor 1-to-1 matching with replacement, which associates the outcome of the treated household with the matched outcome that is given by this 1-to-1 matching method and weighted average of all the non-treated households. Because the weighted average of all the non-treated households is used to construct the counterfactual outcome, 1-to-1 matching method has an advantage of lower variance (Heckman et al., 1998).

A *t*-test was used to compare the mean of each covariate between the treatment and control group after the matching procedure. If the matching was successfully accomplished, the mean difference after matching should be insignificant. The results of the *t*-test showed that the differences in the covariates became insignificant after the matching procedure, which indicates that the observable characteristics of the control group were sufficiently similar to those of the treatment group after matching. The matching quality tests for the entry and exit models suggest that the matching procedures have performed well in terms of avoiding systematic difference in the distribution of pre-treatment observable covariates that are included in the PSM between the treated and non-treated groups.

To check the above results of the match are robust, a sensitivity analysis is performed by using a nearest neighbor 1-to-1 matching method with replacement. The findings confirm that the matching results are quite robust. Although the above results of the PSM indicate that biases from observables are controlled, it might be difficult to infer a causal relationship between diversification and wellbeing as there could still be some unobserved factors that exert certain effects on both farm entry (exit) and households' wellbeing. In addition, farm and non-farm earnings can reinforce each other, which could then influence households' wellbeing through indirect channels such as tightening of the agricultural labor market or raising demand for agricultural products, etc. (Janvry de, 1994; Loening and Mikael, 2009).

7 Propensity scores, balance tests and sensitivity analysis

The characteristics of exit and continue farming households are shown in Table 4. We find that the difference between exit and continue farming was statistically significant in household owned off-farm business, owned land (family farm), access to canal irrigation source and poor village infrastructure. Regarding the household owned off-farm business, exit farmers significantly were less (5%) compared to continued farms (8%). Similarly, we found that the household that exit farms were also those who had family farm (owned land), anyhow these were less (43%) compared to continued farms (77%). We also observe that canal source of irrigation

TABLE 4 Variables, definitions, means, and difference-in-means tests.

Variables	Mean all (N = 925)	Left farming (N = 136)	Continue farming (N = 789)
Education (years)	3.563 (4.430)	3.985 (5.121)	3.490 (4.299)
Number of working age individuals (16–64 years)	2.741 (2.049)	2.441 (1.877)	2.792 (2.073)
Immigrant (Yes = 1)	0.082 (0.275)	0.140 (0.348)	0.072 (0.259)
Household owned off-farm business (Yes = 1)	0.078 (0.268)	0.051 (0.222)**	0.082 (0.275)
Own land (Yes = 1)	0.722 (0.448)	0.426 (0.496)***	0.773 (0.419)
Canal water irrigation (Yes = 1)	0.719 (0.450)	0.596 (0.493)***	0.740 (0.439)
Household affected by natural disasters every year (Yes = 1)	0.366 (0.482)	0.559 (0.498)***	0.333 (0.472)
Crop inputs used as credit (Yes = 1)	0.332 (0.471)	0.331 (0.472)	0.332 (0.471)
Water shortage during seasons (Yes = 1)	0.436 (0.496)	0.419 (0.495)	0.439 (0.497)
Poor village infrastructure (kacha road = 1)	0.256 (0.437)	0.140 (0.348)***	0.276 (0.447)

Notes: Numbers are means; numbers in parentheses are S.D., values. ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

TABLE 5 Variables, definitions, means, and difference-in-means tests.

Variables	Mean all (N = 942)	New entrance (N = 226)	Stay at off farm (N = 716)
Education (years)	3.597 (4.328)	3.717 (4.254)	3.559 (4.353)
Number of working age individuals (16–64 years)	2.431 (1.728)	2.602 (1.705)**	2.377 (1.733)
Immigrant (Yes = 1)	0.039 (0.194)	0.040 (0.196)	0.039 (0.194)
Household owned off-farm business (Yes = 1)	0.149 (0.356)	0.146 (0.354)	0.149 (0.357)
Own land (Yes = 1)	0.034 (0.181)	0.128 (0.335)***	0.004 (0.065)
Canal water irrigation (Yes = 1)	0.728 (0.445)	0.823*** (0.383)	0.698 (0.459)
Household affected by natural disasters every year (Yes = 1)	0.076 (0.266)	0.155 (0.363)***	0.052 (0.222)
Water shortage during seasons (Yes = 1)	0.486 (0.500)	0.376 (0.485)***	0.521 (0.500)
Outstanding loans (Yes = 1)	0.109 (0.312)	0.071 (0.257)*	0.122 (0.327)
Poor village infrastructure (kacha road = 1)	0.167 (0.373)	0.168 (0.375)	0.166 (0.373)
Khal Panchayats system work actively (Yes = 1)	0.076 (0.266)	0.150 (0.358)*	0.053 (0.224)
Local government sharing well climate change knowledge (Yes = 1)	0.717 (0.451)	0.721 (0.449)	0.715 (0.452)
Nearby main commercial market distance (Pacca_road = 1)	0.782 (0.413)	0.788 (0.410)	0.781 (0.414)

Notes: Numbers are means; numbers in parentheses are S.D., values. ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

significantly associated with farm exit (60%), which is lower than farm continuing households (74%). More important, natural disasters significantly increases the percentage of exit farm (56%) which was higher than continued farming (33%). Furthermore, village infrastructure also significantly associated with farm exit, the results show that 14% households exit farming due to poor village infrastructure particularly connection of roads which is mud or kacha road.

Table 5 represents the characteristics of new entrance into farming. We find that the difference between new entrance and stay at farm was statistically significant and higher in new entrance (2.602) compared to stay at farm (2.377). Similarly, we find that the new entrance farms were also those who had owned family farm (owned land) were higher (16%) compared to stay at farm farms (5%). We also observe that canal source of irrigation significantly associated with new entrance and attract new entrance as 82% household enterd into farming due to canal irrigation source. More important, natural disasters significantly associated with new entrance by 15%. Furthermore, Khal Panchayats system significantly attracts 15% new entrance. More important, household affected by natural disasters significantly increases the percentage of exit farm by 56% which was higher than stay at farm farming (33%).

Table 6 presents the logit regression to generate the propensity scores. The goodness of fit can be measured by the pseudo R^2 value, and logit estimation gives a pseudo R^2 of 0.158 in farm exit model. The results indicate that, all other

TABLE 6 Logit regression results (dependent variables are whether the farm exit farm).

Variables	Coef	S.E
Education (years)	0.03	0.02
Number of working age individuals (16–64 years)	−0.03	0.06
Immigrant (Yes = 1)	0.56*	0.32
Household owned off-farm business (Yes = 1)	−0.34	0.44
Own land (Yes = 1)	−1.51***	0.22
Canal water irrigation (Yes = 1)	−1.28***	0.28
Household affected by natural disasters every year (Yes = 1)	0.87***	0.21
Crop inputs used as credit (Yes = 1)	−0.37**	0.22
Water shortage during seasons (Yes = 1)	0.56*	0.27
Poor village infrastructure (kacha road = 1)	−1.04***	0.29
Constant	−0.338***	0.293
LR. chi2	122.13	
P > chi2	0.000	
Log likelihood	−325.136	
Pseudo R^2	0.158	

Note: ***, ** and * are significant at 1%, 5%, and 10% level, respectively.

TABLE 7 Logit regression results (dependent variables are whether the new entrance farm).

Variables	Coef	S.E
Education (years)	0.016	0.020
Number of working age individuals (16–64 years)	0.077	0.047
Immigrant (Yes = 1)	−0.262	0.443
Household owned off-farm business (Yes = 1)	−0.125	0.243
Own land (Yes = 1)	3.086***	0.635
Canal water irrigation (Yes = 1)	1.226***	0.233
Household affected by natural disasters every year (Yes = 1)	0.826***	0.285
Water shortage during seasons (Yes = 1)	−1.265***	0.200
Outstanding loans (Yes = 1)	−0.807*	0.314
Poor village infrastructure (kacha road = 1)	0.176	0.233
Khal Panchayats system work actively (Yes = 1)	0.922***	0.301
Local government sharing well climate change knowledge (Yes = 1)	0.050	0.186
Nearby main commercial market distance (Pacca_road = 1)	0.171	0.218
Constant	−2.117***	0.332
LR. chi2	146.30	—
P > chi2	0.0099	—
Log likelihood	−445.874	—
Pseudo R^2	0.141	—

Note: ***, ** and * are significant at 1%, 5%, and 10% level, respectively.

things being equal in our sample, migration, land ownership, irrigation source (canal), natural disasters, crop inputs used as credit, water shortage during seasons and poor village infrastructure are more likely to be exit farming. Similarly, Table 7 also presents the logit regression to generate the propensity scores and logit estimation gives a pseudo R^2 of 0.141 in new entrance model. The results indicate that, all other things being equal in our sample, land ownership, irrigation source (canal), natural disasters, water shortage during seasons and Khal Panchayats system work actively are more likely to be entrance into farming.

Tables 8, 9 show the results of balancing tests for the PSM with before and after nearest neighbor 1-to-1 matching method (refer to Supplementary Appendix SA2, Supplementary Appendix SA3, Supplementary Appendix SA4). Further we used *t*-test to compare the mean of each covariate between the treatment and control group after the matching procedure. If the matching was successfully accomplished, the mean difference after matching should be insignificant. The results of the *t*-test showed that the differences in most of the covariates became significant after the matching procedure, which indicates that the observable characteristics of the control group were sufficiently similar to those of the treatment group after matching.

Table 10 presents household wellbeing results for entry and exit for three outcome variables (Total household income, Domestic food shortage, and Able to earn money in an emergency) by using nearest neighbor 1-to-1 matching method. The results provide strong evidence that entry decision has significantly and negatively associated with household wellbeing in terms of total household income, whereas positively associated with Domestic food shortage and Able to earn money in an emergency but results are insignificant. The results indicated that households that have entered into farming on average have an annual income Rs. 39,340.8 ($409.79) less than those who have not entered into farming. Furthermore, we find that the standard matching ATTs of Domestic food shortage is positive and statistically insignificant, indicating that entering into farming results in increase in food shortage. However, these results void our hypothesis that entry into farming could be an excellent effort for hushed to be self-sufficient in food security in the future. Turning to farm exit, the ATTs of Able to earn money in an emergency is statistically significant and indicates that households that have exit farming on average have an annual income Rs. 11,716.63 ($122.04) more than those who have not exit farming but the results are insignificant. Furthermore, we find that the standard matching ATT of Domestic food shortage is positive and statistically significant, indicating that exit from farming results increase in food shortage. However, these results are in line towards our hypothesis that exit farming could lead household to be food insecure in the future.

TABLE 8 Results of balancing tests before and after the nearest neighbor 1-to-1 matching with replacement (For exit farming).

Variables	Sample	Mean				*t*-test		V(T)/(VC)
		Treated	Control	% Bias	% Redu. Bias	t	$p>\|t\|$	
Education (years)	Unmatched	3.99	3.49	10.5	—	1.2	0.229	1.42*
	Matched	4.01	3.42	12.7	−21.1	1.02	0.310	1.27
Number of working age individuals (16–64 years)	Unmatched	2.44	2.79	−17.7	—	−1.85	0.065	0.82
	Matched	2.45	2.34	5.8	67.1	0.54	0.592	1.30
Immigrant (Yes = 1)	Unmatched	0.14	0.07	22	—	2.65	0.008	1.80*
	Matched	0.14	0.19	−16	27.3	−1.08	0.280	0.79
Household owned off-farm business (Yes = 1)	Unmatched	0.05	0.08	−12.4	–	−1.24	0.214	0.65*
	Matched	0.05	0.04	6.5	47.3	0.65	0.514	1.43*
Own land (Yes = 1)	Unmatched	0.43	0.77	−75.5	—	−8.66	0.000	1.40
	Matched	0.43	0.39	9.2	87.7	0.71	0.480	1.03
Canal water irrigation (Yes = 1)	Unmatched	0.60	0.74	−31	—	−3.48	0.001	1.26
	Matched	0.60	0.67	−15.8	49.1	−1.26	0.210	1.09
Household affected by natural disasters every year (Yes = 1)	Unmatched	0.56	0.33	46.5	—	5.11	0.000	1.12
	Matched	0.56	0.54	4.2	90.9	0.34	0.736	0.99
Crop inputs used as credit (Yes = 1)	Unmatched	0.33	0.33	−0.3	—	−0.03	0.978	1.00
	Matched	0.33	0.36	−6.1	−2,320	−0.49	0.623	0.96
Water shortage during seasons (Yes = 1)	Unmatched	0.42	0.44	−3.9	—	−0.42	0.674	0.99
	Matched	0.41	0.45	−7.9	−102.2	−0.65	0.517	0.98
Poor village infrastructure (kacha road = 1)	Unmatched	0.14	0.28	−34.1	—	−3.39	0.001	0.60*
	Matched	0.14	0.13	1.7	95.1	0.16	0.874	1.04

Note: ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

Furthermore, we calculated the critical value of $\Gamma^{\dagger}$ (Table 10). For the significant ATTs, the value of $\Gamma^{\dagger}$ total household income is 1.2. It implies that matched entry farmers with the same observed covariates would have to differ in terms of unobserved covariates by a factor of 1.2 for total household income inference of a significant treatment effect. Similarly, in case of farm exit decision, the value of $\Gamma^{\dagger}$ for Able to earn money in an emergency is 1.6. It implies that matched exit farmers with the same observed covariates would have to differ in terms of unobserved covariates by a factor of 1.6 for able to earn money in an emergrncy to invalidate the inference of a significant treatment effect. Therefore, we conclude that the impact estimates are fairly robust to potentially hidden bias. Apel et al. (2010) reported that the estimation results in applied research often become sensitive to Γ value as small as 1.15. However, the results are sensitive to unobserved characteristics of other insignificant ATTs.

8 Conclusion and implications

This article has investigated and identified factors that affect households' farm entry and farm exit based a dataset of 1867 households. This study also investigates the impact of entry and exit decisions on households' wellbeing by using PSM approach for three wellbeing outcomes. This study has brought fresh insights into sustaining rural livelihoods of both the farming and off-farm sectors.

Firstly, our results suggest that household decision of entry into farming significantly decreases household income, while household decision of exit from farming significantly increases domestic food shortage. This finding indicates that farming would be rural household income source in Pakistan. This finding might explain why a larger share (24%) of rural off-farm working labor has shifted into farming as new entrants in Pakistan since 2014.

Secondly, we found that climate shocks could significantly affect farm entry and farm exit decisions, respectively. It is meant that climate shocks could change farmers' future attitudes towards farming. This finding points out a potentially concern as Pakistan agricultural production and livelihoods are particularly vulnerable to climate shocks. In fact, as stated previously, Pakistan's agriculture sector has been faced serious challenges of water shortages and natural disastrous since 2001, and even currently massive floods are still in this country.

TABLE 9 Results of balancing tests before and after the nearest neighbor 1–to–1 matching with replacement (For new entrance into farming).

Variable	Sample	Mean				*t*–test		V(T)/(VC)
		Treated	Control	% Bias	% Redu. Bias	t	$p>\|t\|$	
Education (years)	Unmatched	3.717	3.559	3.7	—	0.48	0.632	0.95
	Matched	3.689	3.726	−0.9	76.7	−0.09	0.929	0.99
Number of working age individuals (16–64 years)	Unmatched	2.602	2.377	13.1	—	1.71	0.088	0.97
	Matched	2.590	2.617	−1.6	87.9	−0.15	0.88	0.74*
Immigrant (Yes = 1)	Unmatched	0.040	0.039	0.4	—	0.05	0.961	1.02
	Matched	0.042	0.018	12.3	−3255.8	1.44	0.15	2.25*
Household owned off–farm business	Unmatched	0.146	0.149	−1	—	−0.13	0.9	0.98
	Matched	0.142	0.123	5.1	−430.4	0.55	0.582	1.12
Own land (Yes = 1)	Unmatched	0.128	0.004	51.4	–	9.38	0	26.89*
	Matched	0.071	0.059	4.9	90.5	0.49	0.623	15.48
Canal water irrigation (Yes = 1)	Unmatched	0.823	0.698	29.5	—	3.7	0	0.69*
	Matched	0.811	0.797	3.3	88.7	0.36	0.716	0.95
Household affected by natural disasters every year (Yes = 1)	Unmatched	0.155	0.052	34.3	—	5.16	0	2.68*
	Matched	0.137	0.166	−9.8	71.6	−0.84	0.401	0.85
Water shortage during seasons (Yes = 1)	Unmatched	0.376	0.521	−29.4	–	−3.82	0	0.94
	Matched	0.392	0.383	1.7	94.2	0.18	0.859	1.01
Outstanding loans	Unmatched	0.071	0.122	−17.2	–	−2.13	0.033	0.62*
	Matched	0.075	0.065	3.6	79.1	0.43	0.67	1.15
Poor village infrastructure (kacha road = 1)	Unmatched	0.168	0.166	0.5	—	0.07	0.946	1.01
	Matched	0.175	0.156	4.9	−848	0.51	0.611	1.09
Khal Panchayats system work actively (Yes = 1)	Unmatched	0.150	0.053	32.6	—	4.86	0	2.55*
	Matched	0.123	0.097	8.4	74.1	0.83	0.408	1.22
Local government sharing well climate change knowledge (Yes = 1)	Unmatched	0.721	0.715	1.4	—	0.18	0.858	0.99
	Matched	0.717	0.724	−1.7	−21.3	−0.17	0.864	1.02
Nearby main commercial market distance (Pacca_road = 1)	Unmatched	0.774	0.750	1.7	—	0.22	0.827	0.98
	Matched	3.717	3.559	5.8	−247.2	0.58	0.565	0.93

Note: ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

TABLE 10 Average treatment effect on ATTs and critical value of Rosenbaum's Γ by using 1-to-1 matching method.

PSM	Variables	Mean treated	Mean control	ATT	S.E.	$\Gamma^{\dagger}$
Farm Entry	Total household income	213,792	258,086	−39340**	21,598	1.2
	Domestic food shortage	0.231	0.248	0.074	0.047	1.0
	Able to earn money in emergency	0.044	0.048	0.003	0.021	1.3
Farm Exit	Total household income	274,526	26,280,99	11,716	51,038	1.1
	Domestic food shortage	0.311	0.205	0.105*	0.047	1.6
	Able to earn money in emergency	0.037	0.079	−0.042	0.032	1.4

Note: ***, **, and * are significant at 1%, 5%, and 10% level, respectively.

Thirdly, descriptive statistics show that approximate 60% of smallholders exited from farming between 2012 and 2014, and 15% of smallholders exit farming after 2014, because they had to sell off their borrowed or credit crop inputs (mainly fertilizer). The major reason is due to the lack of national macro agricultural support policies. In fact, there are more than 80% are samllholders, but the agricultural subsidies (e.g., fertilizer and machinery purchase) are only provided

for large farms (over 12 acres of land) in Pakistan (Ali et al., 2019).

Gernally, agriculture is still major income source for most of rural huseholds and that is why smallholders exist in Pakistan on the one hand. On the other hand, off-farm income also reduces smallholders to exit farming. More importantly, climate shocks and national agricultural support policy can be the crucial factors for smallholders whether to enage in agricultural production.

As with most research, this study has some limitations. For example, we did not discuss whether any household member inherited family farms as a successor or not. We are also unable to identify whether the entrants into farming were permanent or temporary. These questions are also potential for future research.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

MA: Data processing, making draft, revision; LO: Editing, comments; HM: Supervising, comments, editing, and revision; RL: Comments, revision.

Funding

National Natural Science Foundation of China (Grant No. 71403082); National Social Science Foundation of China (Grant No. 14BGL093).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2022.857082/full#supplementary-material

References

Abbasi, S. S., and Kim, T. K. (2018). The factors of migration in Northersn mountain region of Pakistan (A case study of Tehsil Murree, district Rawalpindi. Jordan. *J. Econ. Sci.* 5 (1), 67–75.

Ackoff, S., Bahrenburg, A., and Shute, L. L. (2017). *Building a Future with Farmers: Results and recommendations from the national Young Farmer survey*. Hudson, NY: National Young Farmers Coalition.

ADAS (2004). *Entry to and exit from farming in the United Kingdom: Final report*. London: DEFRA, University of Plymouth, Queen's University Belfast.

Aftab, M., Iftikhar, M., Khan, G. A., and Siddiqui, M. T. (2021). Youth perception and participation in agriculture in district Faisalabad, Punjab, Pakistan. *Int. J. Agric. Ext.* 9, 493–499. doi:10.33687/ijae.009.03.3843

Agarwal, B., and Agrawal, A. (2017). Do farmers really like farming? Indian farmers in transition. *Oxf. Dev. Stud.* 45 (4), 460–478.

Agarwal, B. (2014). *Food security, productivity and gender inequality. Handbook of food, politics and society*. New York, NY: Oxford University Press.

Ahearn, M. C., and Newton, D. (2009). *Beginning Farmers and Ranchers*. Washington, D.C., United States: USDA Economic Research Service. Bulletin Number 53.

Ahearn, M. C. (2011). Potential challenges for beginning farmers and Ranchers. *Choices*. Quarter 2.

Ahmad, M. I., and Ma, H. Y. (2020b). An investigation of the targeting and allocation of post-flood disaster aid for rehabilitation in Punjab, Pakistan. *Int. J. Disaster Risk Reduct.* 44, 101402. doi:10.1016/j.ijdrr.2019.101402

Ahmad, M. I., and Ma, H. Y. (2020a). Climate change and livelihood vulnerability in mixed crop–livestock areas: The case of province Punjab, Pakistan. *Sustainability* 12, 586. doi:10.3390/su12020586

Ahmad, M. I., Oxley, L., and Ma, H. Y. (2020). What makes farmers exit farming: A case study of Sindh province, Pakistan. *Sustainability* 12, 3160. doi:10.3390/su12083160

Ali, A., Rahut, D. B., and Imtiaz, M. (2019). Affordability linked with Subsidy: Impact of fertilizers Subsidy on household Welfare in Pakistan. *Sustainability* 11, 5161. doi:10.3390/su11195161

Ali, H., Shafi, M. M., and Siraj, M. (2014). Determinants of off-farm employment among small farm Holders in rural areas of district Mardan. *Sarhad J. Agric.* 30 (1), 145–150.

Ali, M., and Peerlings, J. (2012). Farm households and nonfarm activities in Ethiopia: Does clustering influence entry and exit? *Agric. Econ.* 43 (3), 253–266. doi:10.1111/j.1574-0862.2012.00580.x

Ali, M., Peerlings, J., and Zhang, X. (2010). *Clustering as an organizational response to capital market inefficiency: Evidence from handloom enterprises in Ethiopia*. Washington, D.C., USA: International Food Policy Research Institute. Discussion Paper Series: 01045.

Apel, R., Blokland, A. A. J., Nieuwbeerta, P., and van Schellen, M. (2010). The impact of imprisonment on marriage and divorce: A risk set matching approach. *J. Quant. Criminol.* 2, 269–300. doi:10.1007/s10940-009-9087-5

Bai, S. B., Wang, J., Lu, G.-N., Zhou, P.-G., Hou, S. S., and Xu, S.-N. (2010). GIS-based logistic regression for land slide susceptibility mapping of the Zhongxian segment in the three Gorges area China. *Geomorphol. (Amst).* 115 (1-2), 23–31. doi:10.1016/j.geomorph.2009.09.025

Barrett, C. B., Reardon, T., and Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics and policy implications. *Food Policy* 26 (4), 315–331. doi:10.1016/s0306-9192(01)00014-8

Benz, A. (2016). Framing Modernization interventions: Reassessing the role of migration and Translocality in sustainable mountain development in Gilgit-Baltistan, Pakistan. *Mt. Res. Dev.* 36, 141–152. doi:10.1659/mrd-journal-d-15-00055.1

Bhandari, P. B. (2013). Rural livelihood change? Household capital, community resources and livelihood transition. *J. Rural Stud.* 32, 126–136. doi:10.1016/j.jrurstud.2013.05.001

Binswanger-Mkhize, H. P. (2013). The stunted structural transformation of the Indian economy. *Econ. Political Wkly.* 48 (26-27), 5–13.

Bruce, A, B. (2019). Farm entry and persistence: Three pathways into alternative agriculture in southern Ohio. *J. Rural Stud.* 69, 30–40. doi:10.1016/j.jrurstud.2019.04.007

Cai, F., and Wang, M. (2010). Growth and structural changes in employment in transition China. *J. Comp. Econ.* 38 (1), 71–81. doi:10.1016/j.jce.2009.10.006

Cain, Mead T. (1977). The economic activities of Children in a village in Bangladesh. *Popul. Dev. Rev.* 3 (3), 201–227. doi:10.2307/1971889

Calo, A. (2018). How knowledge deficit interventions fail to resolve beginning farmer challenges. *Agric. Hum. Values* 35 (2), 367–381. doi:10.1007/s10460-017-9832-6

Calus, M., Van Huylenbroeck, G., and Van Lierde, D. (2008). The relationship between farm succession and farm assets on Belgian farms. *Sociol. Rural.* 48 (1), 38–56. doi:10.1111/j.1467-9523.2008.00448.x

Caskie, P., Davis, J., Campbell, D., and Wallace, M. (2002). *An economic study of Farmer early retirement and new entrant Schemes for Northern Ireland*. United Kingdom, London: Queen's University Belfast.

Chitrakar, P. L. (1990). *Planning, agriculture and Farmers: Strategies for Nepal*. Kathmandu, Nepal: Ganesh Devi Chitrakar.

Conkin, P. (2008). *A Revolution down on the Farm: The transformation of American agriculture since 1929*. Kentucky, United States: University Press of Kentucky.

Davidova, S., and Thomson, K. (2013). Family farming: A Europe and Central Asia perspective. Available at https://kar.kent.ac.uk/id/eprint/64951 (Accessed November 16, 2021).

Deshpande, R. S., and Prabhu, N. (2005). Farmers' distress: Proof beyond question. *Econ. Political Wkly.* 40, 4663–4665.

Eifert, B., and Ramachandran, V. (2004). *Competitiveness and private sector development in Africa: Cross-country evidence from the World Bank's investment climate data*. Ithaca, N.Y. Institute for African Development, Cornell University.

Errington, A., and Lobley, M. "Handing over the Reins: A comparative study of intergenerational farm transfers in England, France, Canada and the USA," in 2002 International Congress, Zaragoza, Spain, August 2002 (Agricultural Economics Society Conference).

Filmer, D., and Pritchett, L. (1997). *Environmental degradation and the demand for Children: Searching for the Vicious Circle (World Bank policy research Paper No. 1623)*. Washington, DC: The World Bank.

Food and Agriculture Organization (2021). *Food and agriculture Organization-FAO statistical Yearbook*. Rome, Italy: FAO.

Frost, J. (2017). *Becoming (and Remaining) a Farmer is Hard*. Boston, USA: Weekly Civil Eats Newsletter.

Gale, H. (2003). Age-specific Patterns of exit and entry in U.S. Farming, 1978-1997. *Rev. Agric. Econ.* 25 (1), 168–186. doi:10.1111/1467-9353.00052

Gillespie, G. W., and Johnson, S. E. (2010). Success in farm start-ups in the Northeastern United States. *J. Agric. Food Syst. Community Dev.* 1 (1), 31–48. doi:10.5304/jafscd.2010.011.008

Gioli, G., Khan, T., Bisht, S., and Scheffran, J. (2014). Migration as an adaptation strategy and its gendered implications: A case study from the Upper Indus basin. *Mt. Res. Dev.* 34 (3), 255–265. doi:10.1659/mrd-journal-d-13-00089.1

Glauben, T., Tietje, H., and Weiss, C. (2006). Agriculture on the move: Exploring regional differences in farm exit rates in western Germany. *Jahrb. für Regionalwiss.* 26 (1), 103–118. doi:10.1007/s10037-004-0062-1

Gruère, G., and Sengupta, D. (2011). Bt Cotton and farmer suicides in India: An evidence-based Assessment. *J. Dev. Stud.* 47, 316–337. doi:10.1080/00220388.2010.492863

Gurung, O. P. (1987). *Inter-relationship among pasture, animal Husbandry and agriculture: Case study of Tara*. Winrock: Kathmandu, Nepal: National Resource Management Paper Series No. 2.

Haggblade, S., Hazell, P., and Reardon, T. (2010). The rural non-farm economy: Prospects for growth and poverty Reduction. *World Dev.* 38 (10), 1429–1441. doi:10.1016/j.worlddev.2009.06.008

Heckman, J., Ichimura, H., Smith, J., and Todd, P. (1998). Characterizing selection bias using experimental data. *Econometrica* 66 (5), 1017–1098. doi:10.2307/2999630

Heckman, J., Ichimura, H., and Todd, P. (1997). Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme. *Rev. Econ. Stud.* 64 (4), 605–654. doi:10.2307/2971733

Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H. A., et al. (2010). Smart investments in sustainable food production: Revisiting mixed crop-livestock systems. *Science* 327 (5967), 822–825. doi:10.1126/science.1183725

Huang, Z., Zhang, X., and Zhu, Y. (2008). The role of clustering in rural industrialization: A case study of the footwear industry in Wenzhou. *China Econ. Rev.* 19 (3), 409–420. doi:10.1016/j.chieco.2007.11.001

Hussain, I. (2014). *Urbanization in Pakistan'*. Karachi: Institute of Business Administration.

Imai, K., Gaiha, R., and Garbero, A. (2014). *Poverty reduction during the rural–urban transformation: Rural development is still more important than urbanization (BWPI Working Paper WP 204/2014)*. Manchester: The University of Manchester.

Ingram, J., and Kirwan, J. (2011). Matching new entrants and retiring farmers through farm joint ventures: Insights from the Fresh Start Initiative in Cornwall, UK. *Land Use Policy* 28 (4), 917–927. doi:10.1016/j.landusepol.2011.04.001

International Food Policy Research Institute (2014). *Pakistan rural household panel survey (PRHPS) 2012, round 1*. Washington, D.C: IFPRI.

International Food Policy Research Institute (2015). *Pakistan rural household panel survey (PRHPS) 2012, round 1.5*. Washington, D.C: IFPRI.

International Food Policy Research Institute (2016). *Pakistan rural household panel survey (PRHPS) 2013, round 2*. Washington, D.C: IFPRI.

International Food Policy Research Institute (2017). *Pakistan rural household panel survey (PRHPS) 2014, round 3*. Washington, D.C: IFPRI.

Jan, I., Khattak, M. K., Khan, M. S., Hayat, S., and Rahim, T. (2012). Factors affecting rural livelihood choices in Northwest Pakistan. *Sarhad J. Agric.* 28 (4), 681–688.

Janvry de, A. (1994). Farm-nonfarm synergies in Africa: Discussion. *Am. J. Agric. Econ.* 76 (5), 1183–1185. doi:10.2307/1243414

Karan, P. P., and Ishii, H. (1995). *Nepal: A Himalayan Kingdom in transition*. Tokyo, New York, Paris: United Nations University Press.

Kimhi, A., and Bollman, R. (1999). Family farm dynamics in Canada and Israel: The case of farm exits. *Agric. Econ.* 21 (1), 69–79. doi:10.1016/s0169-5150(99)00015-8

Knight, J., Deng, Q., and Li, S. (2011). The puzzle of migrant labour shortage and rural labour surplus in China. *China Econ. Rev.* 22 (4), 585–600. doi:10.1016/j.chieco.2011.01.006

Kumar, S. K., and Hotchkiss, D. (1988). *Agricultural production, and Nutrition in Hill areas of Nepal (research report No. 69)*. Washington, DC: International Food Policy Research Institute.Consequences of Deforestation for Women's time allocation

Lobao, L., and Meyer, K. (2001). The great agricultural transition: Crisis, change, and social consequences of twentieth century US farming. *Annu. Rev. Sociol.* 27 (1), 103–124. doi:10.1146/annurev.soc.27.1.103

Loening, J., and Mikael, I. (2009). *Ethiopia: Diversifying the rural economy an Assessment of the investment climate for small and informal enterprises*. World Bank Economic Sector Work. Vol. 49564-ET.

Lusher Shute, L. (2011). *Building a Future with Farmers: Challenges Faced by Young, American Farmers and a national strategy to Help them succeed*. New York: National Young farmers Coalition.

Mishra, A. K., and El-Osta, H. S. (2016). Determinants of decisions to enter the U.S. farming sector. *J. Agric. Appl. Econ.* 48 (1), 73–98. doi:10.1017/aae.2015.25

Mishra, S. (2006). Farmers' suicides in Maharashtra. *Econ. Political Wkly.* 41, 1538–1545.

Pakistan Bureau of Statistics (2018). *Agricultural statistics of Pakistan*. Islamabad, Pakistan: Government of Pakistan, Statistics Division.

Pakistan Bureau of Statistics (2019). *Agriculture statistics of Pakistan*. Islamabad, Pakistan: Government of Pakistan, Statistics Division.

Pietola, K., Vare, M., and Lansink, A. O. "Farmer's exit decisions and early retirement Programs in Finland," in 2002 International Congress, Zaragoza, Spain, August, 2002 (European Association of Agricultural Economists).

Rizwan, M., Deyi, Z., Nazir, A., Ostai, R., Traore, L., and Sargani, G. R. (2017). Determinants and choices of off-farm work among Rice farmers in a developing country. *J. Animal Plant Sci.* 27 (6), 1993–2002.

Rose, E. (2001). Ex ante and ex post labor supply response to risk in a low-income area. *J. Dev. Econ.* 64 (2), 371–388. doi:10.1016/s0304-3878(00)00142-5

Ruan, J., and Zhang, X. (2009). Finance and cluster-based industrial development in China. *Econ. Dev. Cult. Change* 58 (1), 143–164. doi:10.1086/605208

Shahzad, M. A., Abubakr, S., and Fischer, C. (2021a). Factors affecting farm succession and occupational choices of Nominated farm successors in Gilgit-Baltistan, Pakistan. *Agriculture* 11 (12), 1203. doi:10.3390/agriculture11121203

Shahzad, M. A., Ahmed, V., and Fischer, C. (2021b). Status and determinants of other gainful activities by farmers in mountainous rural regions of Gilgit-Baltistan, Pakistan. *J. Mt. Sci.* 18, 2520–2539. doi:10.1007/s11629-021-6673-y

Sianesi, B. (2004). An evaluation of the Swedish system of active labor market Programs in the 1990s. *Rev. Econ. Statistics* 86 (1), 133–155. doi:10.1162/003465304323023723

State Bank of Pakistan (2015). *Annual report 2014-2015 (state of the economy)*. Pakistan, Karachi: State Bank of Pakistan.

Tahir, M., Khan, H., and Qahar, A. (2012). Factors determining off-farm employment on small farms Iin district Nowshehra of North west Pakistan. *Sarhad J. Agric.* 28 (2), 333–344.

Vare, M., and Heshmati, A. (2004). *Perspectives on the early retirement decisions of Farming Couples*. Bonn, Germany: Institute for the Study of Labor. Discussion Paper No. 1342.

Wang, X., Huang, J. K., Zhang, L. X., and Rozelle, S. (2011). The rise of migration and the fall of self employment in rural China's labor market. *China Econ. Rev.* 22 (4), 573–584. doi:10.1016/j.chieco.2011.07.005

Whitehead, I., and Millard, N. (2000). *Contemporary issues of county farm estates in England and Wales*. London, United Kingdom: Royal Institute of Chartered Surveyors.

Williams, F., and Farrington, J. "Succession and the future of farming: Problem or perception?," in Conference on the Rural Citizen: Governance, Culture and Wellbeing in the 21st Century, Plymouth, UK, 2006 (University of Plymouth).

Wooldridge, J. M. (2009). *Introductory Econometrics: A modern approach*. OH, USA: South-Western Cengage Learning: Mason.

World Bank (2007). *China's modernizing labor market: Trends and emerging challenges*. Washington, D.C., United States: World Bank. Synthesis Report for the ESW Component of the China Labor Market AAA Program.

World Bank (2008). *World development report 2008: Agriculture for development*. Washington, D.C., United States: World Bank Publications.