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Farm risks, livelihood asset allocation, and adaptation practices in response to climate change: A cross-country analysis

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This study aims to understand the impact of farmers' risk attitude on livelihood assets and their livelihood adaptation strategies to cope with climatic changes. An interview-based survey with farmers is conducted in China and Pakistan, using probit regression models to analyze the data. The results confirm that Pakistani growers' natural and policy risks, whereas technology and information risks in China, are the main livelihood risks to farm production. Farmers' natural, physical, social, and human assets in China and Pakistan's financial, physical, and social assets can protect their livelihoods from farm risks. Pakistan's physical, social, and economic assets and China's physical, human, and social assets show contradictory effects. Although farmers in China adopted agrotechnical support, off-farm production, crop variety adjustment, and agricultural engineering, Pakistan's growers adopted agricultural finance, fertilizer/water management, and adjustment of crop varieties to deal with risks. In addition, social, natural, human, and physical assets revealed significant and positive impacts on Pakistani growers; physical and financial assets positively affect Chinese farmers' attitudes. Despite Chinese growers' human, social, and natural assets, Pakistani farmers' financial and natural assets show comparatively weak effects to adapt and deal with climatic risks. Furthermore, this study recommends agricultural policy measures to cope with climate awareness and adaptive attitudes, and potential practices can be introduced in both studied areas.

KEYWORDS

livelihood assets, adaptation strategies, climatic risks, food security, SLF, China and Pakistan natural risks −0.700 0.427** 0.364** 0.491****

Introduction

Smallholder farming practices significantly reduce poverty and promote rural development on a global scale. Climate change poses a significant challenge and multiple risks to farms, with severe impacts on smallholder's food security and livelihoods, especially those in developing countries. Hence, the growers in developing countries are subjected to various climatic risks and threats, including natural catastrophes, market fluctuations, land degradations, and environmental epidemics, locking agrarians in a cycle of prolonged deprivation (van den Berg, 2010). Meanwhile, continuous climate variability and catastrophes cause punitive stresses, risking agricultural production, household livelihoods, and survival (Jezeer et al., 2019). As a result, climate change constantly impacts natural agricultural rangelands and exposes rural livelihoods to increased vulnerability consequences in food security (Sargani et al., 2021b; Ghazali et al., 2021; Loi et al., 2022). Particularly in developing countries, these risks of livelihood assets result from the increasing inclination to smallholder farmer's outcomes (Fang et al., 2014; Qasim et al., 2015; Cao et al., 2016), boost yield and productivity, increase agricultural sustainability, and attenuate climatic change to minimize greenhouse emissions. The farming community copes with this climatic variability to prioritize and assess the changing climate consequences on agriculture, forestry, and land-use practices to ensure food security and reduce poverty in developing economies (Sargani et al., 2020).

Therefore, a sustainable livelihoods index concept of livelihoods has been adopted in the model aimed at researching rural livelihoods (Li et al., 2017a; Pandey et al., 2017). In the meantime, Scoones (1999) expanded on Chambers' (1988a) notion of asset allocation by emphasizing livelihood assets as the principal component of a sustainable livelihood framework. This approach understands farmers as earning a living in a vulnerable situation, and farmers may enhance economic livelihoods by using particular assets with diversified strategies (Wu et al., 2017; Baffoe and Matsuda, 2018) because this livelihood asset serves as a foundation for not just farmers' agricultural production decisions but also for households' capacity to manage livelihood vulnerability and risks of rural farms (Fang et al., 2014; García de Jalón et al., 2018; Liu et al., 2018; Zhifei et al., 2018).

Generally, farmers may adopt mitigation practices and strategies to alleviate the consequences of unfavorable impacts on their farm livelihoods (Elum et al., 2017). Usually, growers' livelihoods have been influenced by climate change; therefore, appropriate adaptation strategies minimize the adverse effects of the risks mainly faced by farmers in farm production (Alam et al., 2016; Khanal et al., 2018b; Zhai et al., 2018). Farmers' adaptation tactics may be improved by studying the factors influencing farmers' adoption strategies to enhance their livelihoods. Crop diversification yielded the best practice for adapting to climate change that improves farmer wellbeing and local food security (Abid et al., 2016). Thus, the farmer characteristics can be age, gender, and education; family factors (numerous studies have looked at population and total family income); and cognitive attributes (climate change cognition) (Jianjun et al., 2015; Alam et al., 2016; Li et al., 2017b; Khanal et al., 2018b; Sargani et al., 2021b). However, a few studies have examined the impact of farmers' livelihood assets on their propensity to use such adaptation strategies.

In comparison, the growers' attitude is centered on assessing their resources and assets for a living in the light of recent studies (Fang et al., 2014; Wu et al., 2017; García de Jalón et al., 2018). As a result, smallholder farmers in developing nations face several risks and challenges (Schroth and Ruf, 2014; Khanal et al., 2018a); such risks can be mitigated by using sources of livelihood to adopt adaptation practices that optimize the economic efficiency of production (Jezeer et al., 2019; Sargani et al., 2021a). To rely on "take-make-dispose" practices has had appalling effects on the environment, and effective use of assets and resources by rethinking and redesigning agrarian economies may be an excellent chance to improve rural wellbeing in China and Pakistan.

This article focuses on China and Pakistan since they are two of the most populated nations in the world and have many similarities in their agricultural practices. Concerns about population growth and past famines have brought Pakistan and China closer together on matters of rural poverty. Comparison of the effects of political, economic, infrastructural, and cultural variations in China and Pakistan is extensively studied; despite a plethora of government policies and distortions, market prices continue to serve as the most critical indicator of whether or not a given set of agricultural practices is profitable. However, having identical economic objectives, the two nations' institutions and policies diverge significantly in the case of farming; as a direct source of revenue, both countries relied on agriculture for their rural livelihoods. However, its comparative livelihood risk, asset allocation, and adaptation strategies evidence have not yet been addressed. Therefore, this is the first approach to understand and investigate farmers' climate change risk attitudes, adaptation strategies, and asset allocation in light of cross-country contexts to counter the following questions. To what extent do the farmers adapt to allocate their capital and assets to cope with climate change? What is the state of farmers' livelihood asset allocation practices in the study area? To what extent do assets impact farmers' climate change adaptation strategies and risk attitudes? Finally, relevant policies begin to better assist farmers in adopting adaption practices to minimize livelihood risks and improve and enhance farm production to sustain the livelihoods of rural households.

Literature review and model paradigm

Climate change is a pressing concern for governments, farming society, and academia. According to the Food and Agriculture Organization (FAO), global climate change is a crucial problem that must be addressed with good practices to ensure food supply, access, utilization, and stability (FAO, 2018). Therefore, basic human needs should be addressed more

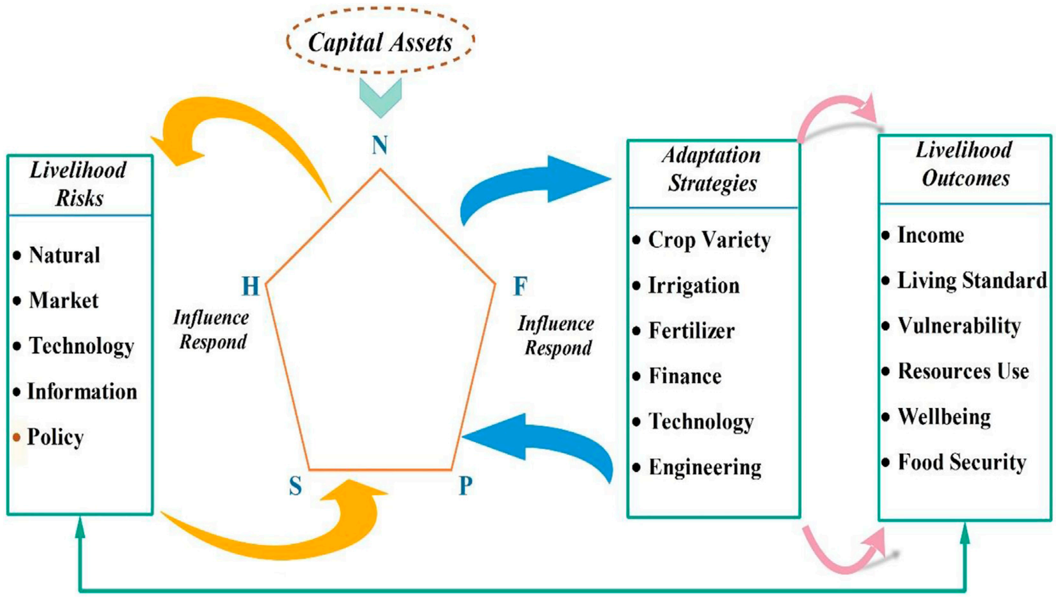

FIGURE 1
Study framework of farmers in China vs. Pakistan.

effectively, and asset allocations, strategies, and practices in the farming sector must be optimized to address basic human needs. It is necessary to rethink, redesign, and reconceptualize agrarian economies to guide research into the relationship between livelihood risks, livelihood assets, and adaptation strategies for growth and production. Figure 1 depicts the structure to investigate this subject matter.

Generally, growers in developing countries seem more prone to situations that expose individuals to exposure or livelihood risks, leading to fragility (Qasim et al., 2015; Alam et al., 2016; Ajak et al., 2018). Landowners are more sensitive to climatic risks because of their limited access to resources and assets (Jin et al., 2015; Baffoe and Matsuda, 2018). Moreover, the fragility of growers' livelihoods might make the use of resources and assets increasingly challenging. Thus, farm owners can get rid of such a protracted vicious loop that can diminish, endangering the viability of their livelihood (van den Berg, 2010).

As a result of carefully weighing all of its financial and other resources, farmers make agricultural choices (Scoones, 1999; Baffoe and Matsuda, 2018). According to an expert (Chambers, 1988b), sustainable livelihoods may be modeled on economic, human, natural, physical, and social assets. Such financial and social support and capital mainly influence farmers' farm production in Ethiopia's Nile basin (Deressa et al., 2009; Chen et al., 2014). Specifically, in China (Kuang et al., 2019), natural and social capital impacts farmers' climate change adaptation decisions, whereas human and physical capital encourages farmers to adapt. Therefore, farmers may adopt adaptation strategies to increase agricultural productivity if they develop across all five classes of assets, mainly social and human assets considered an integral part of their farm development (García de Jalón et al., 2018).

Usually, farmers may face fewer climatic livelihood risks. At the same time, they practice balancing their asset allocation with adaptation techniques that may more occasionally influence livelihood risks on their livelihoods that may bring fruitful farm production. Therefore, in that theme, the main focus of this research is to investigate the impact of livelihood assets on farmers' farm adaptation strategies and livelihood risk attitudes. It addresses the policy implications of reducing livelihood risks and encouraging adaptation mechanisms to the maximum degree feasible within agricultural production systems in China and Pakistan, respectively.

Quantifying livelihood assets

Agricultural producers of farm livelihood assets in China and Pakistan are indicated in Table 2 and Figure 3. Due to the nature of farm business, rural households have different investment attitudes and more diverse enterprise portfolios than families in other regions as the climate changes, and their asset allocation strategy may also change. Therefore, assessing farmers' pentagon of livelihood assets is considered to be the allocation of a significant factor to cope with climatic risks, mitigation adaptation, and a choice of specific indicator studies (Fang et al., 2014; Li et al., 2017a; Li et al., 2017b; García de Jalón et al., 2018; Jezeer et al., 2019) were used as references.

TABLE 1 Demographic indicators of the sample.

Context	China				Pakistan			
	N = 317	% Age	M	S.D	N = 290	% Age	M	S.D
Farmer age	36	11.4	3.511	1.328	18	6.2	3.66	1.23
<25								
25–30	35	11.0			44	15.2		
30–40	73	23.0			46	15.9		
40–50	77	24.3			94	32.4		
>50	96	30.3			88	30.3		
Education	27	8.5	3.088	1.147			3.05	1.49
Illiterate					80	27.6		
Primary	75	23.7			18	6.2		
High school	97	30.6			55	19.0		
Undergraduate	79	24.9			82	28.3		
Graduate	39	12.3			55	19.0		
Household size			2.732	1.38			3.49	1.23
1–3	85	26.8			37	12.8		
4–6	62	19.6			11	3.8		
7–9	61	19.2			76	26.2		
8–12	71	22.4			105	36.2		
>12	38	12.0			61	21.0		
Engaged in farming (yrs)			3.35	1.131			3.41	1.26
1–5	15	4.7			23	7.9		
5–10	66	20.8			61	21		
10–15	84	26.5			43	14.8		
15–20	97	30.6			99	34.1		
>20	55	17.4			64	22.1		
Farm area (ha)			3.151	1.148			3.08	1.32
1–5	22	6.9			49	16.9		
5–10	78	24.6			50	17.2		
10–15	91	28.7			66	22.8		
15–20	82	25.9			80	27.6		
>20	44	13.9			45	15.5		
Annual net income			3.369	1.185			3.24	1.26
<1,000	16	5.0			23	7.9		
1,000–2,000	72	22.7			78	26.9		
2,000–4,000	73	23.0			51	17.6		
4,000–5,000	91	28.7			81	27.9		
>5,000	65	20.5			57	19.7		

N=sample, % Age = percentage, M = mean, S.D = std. deviation.

Natural assets: Natural assets are the resources and services humans depend on for existence and growth (Pandey et al., 2017). The land, water, and biological resources are more critical to farm community sustenance than any other natural resource among farmers' most crucial natural assets. In light of Sargani et al.'s (2020) study that natural asset endowments may be a contractual obligation to act, each household's amount of leased land may correctly reflect producers. As a result, farmer-planted land comprises both contracted and transferred property. To begin with, the findings of Wu et al. (2017) show that the cultivation area of farmland is selected as a proxy measure of land value since crop fields are the best kind of cultivated land. Simultaneously, the government encourages landowners to accomplish large-scale management using land rotation.

Financial assets: Financial or economic assets are the equities and investments primarily represented by the total money in stocks, savings, and credits (García de Jalón et al., 2018). The household has the ability to allocate different types of

TABLE 2 Correlation matrix of farm assets allocation in China vs. Pakistan.

Assets	Natural assets	Financial assets	Physical asset	Social asset	Human assets
Natural assets	--	0.544[a]	0.682[a]	0.283[a]	0.621[a]
Financial assets	0.401[a]	<.001	<.001	<.001	<.001
	<.001	--	0.640[a]	0.299[a]	0.597[a]
Physical asset	0.506[a]	0.477[a]	<.001	<.001	<.001
	<.001	<.001	--	0.237[a]	0.662[a]
Social asset	0.172[a]	0.264[a]	0.253[a]	<.001	<.001
	0.002	<.001	<.001	--	0.325[a]
Human assets	0.398[a]	0.487[a]	0.518[a]	0.354[a]	<.001
	<.001	<.001	<.001	<.001	--

[a]Correlation is significant at the 0.01 level (two-tailed).

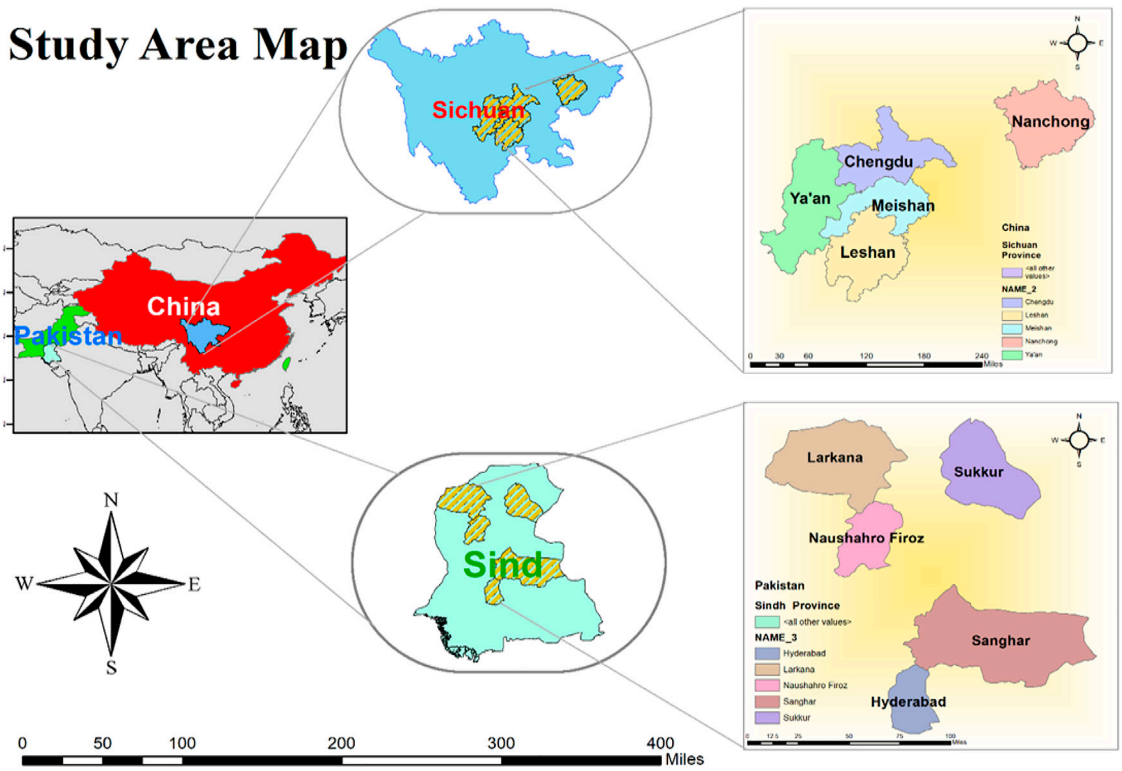

FIGURE 2
Map of the study area.

farm production. Accordingly, overall family revenue and household earning capacity reflect the amount and reliability of the landowner's income. The intensity associated with financial assistance demonstrates the likelihood of farmers acquiring monetary credit support and providing excellent financial aid to avoid farm risks and vulnerabilities to implement alternate production practices and earn more revenue.

Physical assets: Physical assets primarily relate to basic infrastructural facilities that enhance agricultural output and livelihood (Pandey et al., 2017). Economic production processes create this asset with aggregate quality of agricultural farm equipment, and implements reflect farm owners' input for agricultural output. It also improves agricultural production efficiency by constructing irrigation canals (García de Jalón et al., 2018). The number of air

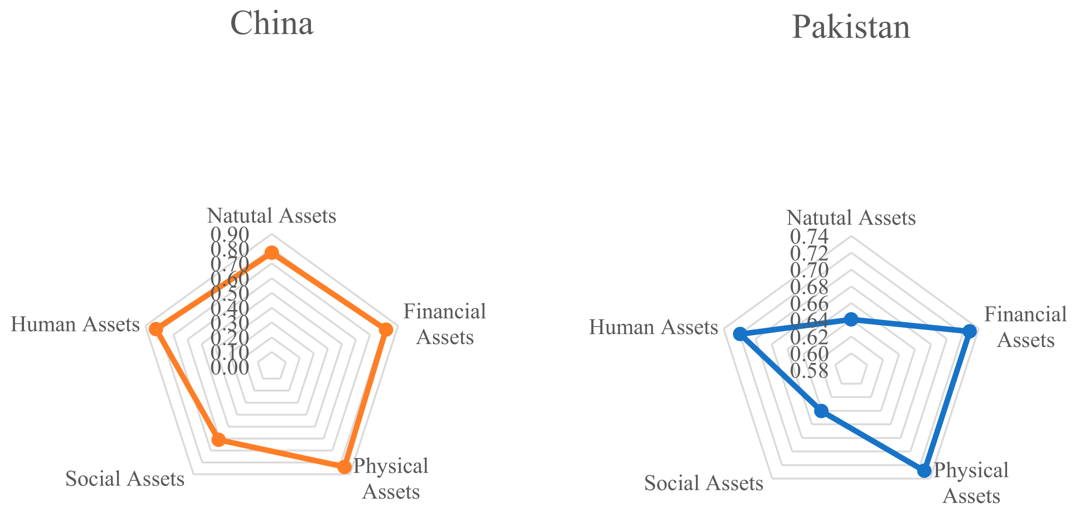

FIGURE 3
Pentagon of grower's livelihood assets in China and Pakistan.

conditioning units and cars may be a good indicator of farmers' physical asset allocation since they help agriculturalists increase their productivity and livelihood while also improving the lives of farm residents to attain socio-environmentally holistic livelihoods.

Social assets: The social asset is a system of social interactions between people or organizations and connections, i.e., formal and informal networking, to enhance ranch productions (Baffoe and Matsuda, 2018; García de Jalón et al., 2018). Particularly in rural societies of China, places with a high premium on collectivism and a family name are critical components (Li et al., 2017a). A similar scenario exists in Pakistan's farm society, where growers often share their experiences and knowledge about agricultural livelihoods with great significance to sustainably solving rural households' poverty (Sargani et al., 2022). This sense of interdependence between neighbors contributes to developing a favorable atmosphere for engagement and participation in the farm business, which is critical for exchanging existing agricultural expertise to boost farm productivity.

Human assets: Human assets almost entirely comprise one's knowledge, abilities, vitality, and workforce competencies (Baffoe and Matsuda, 2018). The size and quality of the workforce are two critical indicators in the literature (Fang et al., 2014). Human and labor assets are generally essential for farmers pursuing effective livelihood choices. The adoption of this indicator is hugely valuable in areas where human–environment connections have a significant impact on livelihood prospects. Additionally, professional development is a method of obtaining information (Jezeer et al., 2019). Thus, together with the share of the household labor force and the education and occupation attained by family members, farming development of deep learning is often used to measure the labor force existing in the family, its health, and education and use of their services to improve farm income.

Livelihood asset allocation techniques and decision-making options are pillars for bringing incentives across individual, home, and community goals. Social aims often trump economic considerations (King, 2011; Carr, 2013) with the notion of "producing value co-creation," depending on the economic ecology paradigm, outlining the building of livelihood strategies that adapt to local limits and incentives while being nested in larger structures and dynamics (Batterbury, 2001). This may be carried out by diversifying agricultural practices and activities in conjunction with developing social service capabilities, which can lessen their reliance on natural capital assets (Batterbury, 2001). The livelihood reality is referred to as the livelihood result, which affects future livelihood wellbeing as long as the farm community's production mechanism continues to operate as sustenance, which is critical for maximizing improved livelihoods and sustainable development.

Material and methods

Data collection and survey design

In this study, three phases were involved in creating the survey questionnaire. Our first survey questionnaire was devised after conducting a literature study to assess farmers' livelihood risks, adaptation options, and livelihood assets. Second, we undertook a series of focus group discussions (FGDs) with five sustainable livelihood indices, government officials, and farmers. The preliminary questionnaire was based on some of the suggestions from the conversations. Third, a presurvey was conducted to ensure farmers knew the study topics. We changed and improved our inquiry for further assessments based on the presurvey responses.

Questionnaire measurement

The final research is divided into three categories. The first portion examines farmers' attitudes and cognitions of possible livelihood risks in agricultural output. Next, the farmers' adaptation techniques' effectiveness in dealing with various climatic livelihood risks is evaluated. Finally, to improve long-term livelihoods for farmers in the face of climate change, the third component conducts in-depth research on their natural, financial, physical, social, and human assets and how they use them in agricultural production.

Study area and sample size

The sample size assumes a pivotal role in data analysis consistent with substantial estimates, explanation of results, and objective achievement in validating estimates and describing meaningful outcomes (Leguina, 2015; Sargani et al., 2021a). Therefore, an appropriate and adequate sample size from the target population is attained by adopting the formula of Yamane (1967), which is presented as follows:

$$\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1} + \mathbf{N}(\boldsymbol{\delta})^2}. \tag{1}$$

In this equation, n represents the projected sample size, δ signifies the margin of error, and N characterizes the intended population of farm families.

In light of this, farmers in China's Sichuan Province and Pakistan's Sindh province were chosen using a multistage stratified random selection approach. Five areas (Chengdu, Ya'an, Meishan, Leshan, and Nanchong) from Sichuan were chosen first. The strata included five districts, i.e., (Naushahro Feroze, Sukkur, Larkana, Mirpurkhas, and Hyderabad) from Pakistan's Sindh province, as shown in Figure 2. Then, villages were randomly picked from each town to serve as survey sample locations. Finally, approximately 50 families were chosen randomly from each hamlet for the survey questionnaires. In this study, participants were referred to as "head of household" or "farm decision-maker." We trained the research team members early on, and the team members performed face-to-face interviews with the farmers who were questioned to get critical information. Overall, 350/350 interviews were carried out in each signatory country. After removing scarce evidence from the questionnaire (317 from China and 290 from Pakistan), 607 valid questionnaires were obtained from the investigation, and the overall survey had 87% response rate recorded.

Data analysis

Correlation coefficient assessment

Correlation is often used in asset allocation management and risk estimation. Correlation analyzes the degree of association between two predictor factors measured by the coefficient of correlation, which is a significant risk indicator. The formula for correlation is equal to the covariance of return of asset 1 and covariance of return of asset 2/standard deviation of asset 1 and a standard deviation of asset 2.

$$\boldsymbol{\rho_{xy}} = \frac{\boldsymbol{Cov(r_x, r_y)}}{\boldsymbol{\sigma_x \sigma_y}}, \tag{2}$$

where

ρ_{xy} = correlation between two variables

$Cov(r_x, r_y)$ = covariance of return X and covariance of return of Y

σ_x = standard deviation of X

σ_y = standard deviation of Y

Correlation is based on the cause-of-effect relationship, and there are three kinds of correlation in the study, widely used and practiced.

Positive correlation—a positive correlation exists between two variables when they are said to move in the same direction.

Negative correlation—there is a negative correlation between two variables when the variables change in the opposite direction.

No correlation—there exists no correlation between two variables when there is no movement of a direct relationship between the two variables.

Probit model estimation

Regression models investigate the relationship between livelihood assets, livelihood risks, and adaptation options. More specifically, five different livelihood assets are used as explanatory variables in this study. According to this equation, the dependent variable is 1 if the farmer is exposed to livelihood risks and 0 otherwise, to study the relationship between livelihood assets and farmer's livelihood risks. Regarding assessing the effect of livelihood assets on farmers' adaptation strategies, the dependent variable equals 1 if a household has selected an adaptation strategy and 0 if the farm has not chosen an adaptation approach. This is because, in nature, livelihood risks and adaptation techniques are either/or propositions expressed in binary terms (van Zanten and van Tulder, 2018). A summary of the model is as follows:

$$y = \alpha + \beta i \sum_{i=1}^{n} x_i + \varepsilon. \quad (3)$$

Wherein y is a binary interpretation indicator (representing either farmer subjected to livelihoods risk or adopting a risk management approach). The coefficients that need to be estimated are x_i representing the explanatory variable (which includes five different types of livelihood assets), and ε signifies the error term.

Farmers' socio-economic typology

Generally, the growers' demographic features with the respondents' significant socio-economic aspects were investigated and are shown in Table 1. The respondents' age varied from 18 to 96 years old, with an average of roughly 58–64 years in Pakistan and China. The respondents' average educational level was notoriously low from elementary to junior middle school. Approximately 31% of Chinese growers had 10–20 years of experience, and 34% of Pakistani peasants showed farming experience; this indicated that they had mostly been active in agricultural production. Such findings reflect the reality in China and Pakistan, where farmers are often elderly, have poor educational levels, and have been involved in agriculture for a long time. According to the data, the average household size polled was 10–15 of the Chinese farmers with a cultivated land area of 29% of hectares. Similarly, about 28% of the land area in Pakistan is grown by 15–20 farmers. The producers polled had an average yearly gross revenue of 4k–5k, with a recorded 29% of Chinese growers' income, while Pakistani farmers show their 1k–2k gross revenue of 27%.

Correlation matrix coefficient

The correlation matrix represents the degree of relationship to determine the linear link between variables. Correlation values range from −1 to +1. A positive correlation indicates that two variables rise and fall together, and when one variable increases and another decreases, there is a negative connection. Therefore, we measured the correlation matrix to identify the degree and direction of a relationship between variables. The correlation matrix in Table 2 shows that all the farm assets in the lower diagonal of Chinese farmers' assets have a positive association. Similarly, as in the upper diagonal for Pakistani farmers, assets are positively correlated with all other factors.

We also compared the farm adoption strategies between China and Pakistan in Table 3, which shows that the lower diagonal, except for agricultural engineering with crop variety adjustment, shows a negative association. However, water/fertilizer management and off-farm production are significantly related to crop variety adjustment, although agrotechnical support, agricultural engineering, and off-farm production are positively correlated with agricultural finance; in the same view, farm engineering and off-farm production show a significant positive connection with agrotechnical support. While in the upper diagonal of Table 3 the result shows that the crop variety adjustment has a positive relationship with water/fertilizer management, whereas the agricultural finance with agrotechnical support and agricultural engineering. Last, agrotechnical support reveals a significant positive relationship with Chinese growers' off-farm production practices.

We examined the farmers' risk correlation between Chinese farmers' market risks, technology risks, and information risks, revealing a significant positive correlation between natural risk and technology risk, information risk, and policy risk, positive signs with market risks; however, policy risk with market risks, technology risk, and information risk is in the lower diagonal matrix of Table 4. Whereas for Pakistani grower's correlation risk show in the upper diagonal matrix of Table 4 that, natural risks with market risks, technology risks with natural risks and market risks, information risk with natural risks, market risks and technology risk, while the policy risk with natural risks, market risks technology risk, and information risk are positively significant to each other.

Results

Growers' livelihood assets

A central notion is that farmers have access to other livelihood assets, in which the household had tradeoff choices and strategies comprising the farm business. The landowner's livelihood assets were distributed based on the mean value of the five livelihood assets of Chinse and Pakistani growers' asset allocations shown in Figure 3. We examined each kind of livelihood asset's mean values. The findings reveal that human assets are more valuable than natural assets, financial assets are more encouraging than social assets, and physical assets are more valuable than financial assets in both countries. Although farmers' human, financial, and natural assets, on the other hand, are valued by Chinese farmers, Pakistani farmers' physical, economic, and social assets are an insufficient source for their farming livelihoods.

Farmers' livelihood risks and adaptation strategies

When growers are active in agricultural production, the study findings reveal that most farmers are sensitive to livelihood risks posed by natural disasters, the market, technology, information, and policy risks. As seen in Table 5, most farm practices are influenced by natural and market risks when managing their agricultural businesses. Furthermore, almost 64% of Pakistani and roughly 41% of

TABLE 3 Correlation matrix of farm adoption strategies Pakistan vs. China.

Strategy	Crop variety adjustment	Water/ fertilizer management	Agricultural finance	Agrotechnical support	Agricultural engineering	Off-farm production
Crop variety adjustment	--	0.146[a]	−0.011	−0.077	−0.026	−0.015
Water/fertilizer management	0.160[a]	0.009	0.849	0.173	0.644	0.789
	0.006	--	−0.101	0.034	−0.012	−0.016
Agricultural finance	0.013	0.030	0.074	0.548	0.826	0.780
	0.830	0.616	--	0.308[a]	0.326[a]	0.076
Agrotechnical support	0.058	0.049	0.452[a]	<.001	<.001	0.174
	0.326	0.407	<.001	--	0.145[a]	0.111[b]
Agricultural engineering	−0.093	0.067	0.508[a]	0.125[b]	0.01	0.049
	0.116	0.255	<.001	0.034	--	0.046
Off-farm production	0.233[a]	0.076	0.163[a]	0.197[a]	0.006	0.415
	<.001	0.195	0.005	<.001	0.922	--

[a]Correlation is significant at the 0.01 level (two-tailed).
[b]Correlation is significant at the 0.05 level (two-tailed).

TABLE 4 Correlation matrix of farmers' risks in China vs. Pakistan.

Farm risk	Natural risks	Market risks	Technology risk	Information risk	Policy risk
Natural risks	--	0.700[a]	0.427[a]	0.364[a]	0.491[a]
		0.000	0.000	0.000	0.000
Market risks	0.533[a]	--	0.516[a]	0.424[a]	0.567[a]
	0.000		0.000	0.000	0.000
Technology risk	0.398[a]	0.422[a]	--	0.212[a]	0.382[a]
	0.000	0.000		0.000	0.000
Information risk	0.281[a]	0.314[a]	0.173[a]	--	0.667[a]
	0.000	0.000	0.002		0.000
Policy risk	0.392[a]	0.434[a]	0.256[a]	0.563[a]	--
	0.000	0.000	0.000	0.000	

[a]Correlation is significant at the 0.01 level (two-tailed).

Chinese farmers are subject to genuine concerns in producing agricultural products. In contrast, more than 63% of Pakistani and 38% of Chinese producers stated that their agricultural output was subject to market concerns. Moreover, farmers also perceived themselves as being exposed to technology, information, and policy risks due to their involvement in agricultural production; approximately 49%, 47%, and 42% faced Chinese farmers, and almost 63%, 64%, and 67% of livelihood risks posed by Pakistan growers in the agricultural productions, respectively. Because of this, farmers have devised a few adaptation strategies to cope with climatic dangers and threats to their livelihood, and those adaptive strategies were classified based on earlier study findings (Sargani et al., 2022; Alam et al., 2016; Khanal et al., 2018b) and focus group discussions (FGDs). In addition, half of the farmers said they had used one adaptation approach. To characterize farmers' attitudes toward adaptation to climate risks, the following factors were considered: crop variety selection and management, water and fertilizer management, agricultural finance, agrotechnical help, agrarian engineering, and off-farm business presented in Table 6 shows how farm households have used a range of adaptive measures.

The most widely used adaptive practice was water and fertilizer management 80% by Chinese farmers, and Pakistani growers adopted crop variety adjustment strategy with 66% to enhance farm production. Furthermore, approximately 67% of Chinese and 60% of Pakistani farmers used agrotechnical assistance and support. About 70% of Chinese growers and 58% of Pakistan farmers used agricultural finance, including agri-engineering strategy; about 70% of Chinese and about 62% of Pakistani farm owners adopted this approach, while more than 70% of Chinese and 65% of Pakistani peasants changed crop types to off-farm productions. As for adaptive

TABLE 5 Analysis of livelihood risks attitudes of growers in China vs. Pakistan.

Risk type	Risk attitudes	China			Pakistan		
		% Age	M	S. D	% Age	M	S.D
Natural risk	Risk of farmers being exposed to irregular changes in natural forces, e.g., climate change and natural risks	41.009	0.410	0.493	64.138	0.640	0.480
Market risk	Risk of farmers being exposed to the unstable market in agricultural production, such as sales and prices	38.170	0.380	0.487	64.138	0.640	0.480
Technology risk	Risk of farmers being exposed to a lack of or misusing agricultural technologies	49.211	0.490	0.501	63.103	0.630	0.483
Information risk	Risk of farmers being exposed to incorrect or missing information in agricultural production	47.003	0.470	0.500	63.793	0.640	0.481
Policy risk	Risk of farmers being exposed to national or local policy changes in agricultural production	42.902	0.430	0.496	66.552	0.670	0.473

TABLE 6 Coping risk adaptation strategies by growers in China vs. Pakistan.

Adaption type	Adaptive attitude	China			Pakistan		
		% age	M	S. D	% age	M	S.D
Crop variety adjustment	Planted new or other varieties, diversified planting (planting a variety of agricultural products)	66.552	0.710	0.455	66.552	0.670	0.473
Water/fertilizer management	Adopted the land protective utilization behavior, such as straw returning to the field or using farmyard manure	80.757	0.810	0.395	63.448	0.630	0.482
Agricultural finance	Sought agricultural credit or purchased agricultural insurance	70.978	0.710	0.455	57.586	0.580	0.495
Agrotechnical support	Strengthened agricultural technologies, accepted the assistance provided by the government, and sought the help of network technology	67.192	0.670	0.470	60.690	0.610	0.489
Agricultural engineering	Transformed the agricultural infrastructure, improved the ecological environment around the farmland, transformed the natural conditions of planting, such as topography, etc.	70.978	0.710	0.455	62.759	0.630	0.484
Off-farm production	Sought the development of non-agricultural or off-farm industry or withdrawn from agriculture	70.662	0.710	0.456	65.172	0.650	0.477

% age = percentage, M = mean, S.D = std. deviation.

techniques, fewer Pakistani farmers used agricultural finance, agricultural engineering, or developed off-farm or non-agricultural output compared to Chinese farmers for their agricultural production.

Growers' livelihood risks and livelihood assets nexus

Based on the model's findings, Table 7 represents the model's results for the relationship between livelihood assets and farmer livelihood risks. The chi-square test findings reveal that the likelihood ratio statistics of all five models are statistically significant at the 1% level, suggesting that the data fit well with each model as a whole and that the models have substantial predictive power (Menard, 2011). This research has found that the results for most livelihood assets are statistically significant at 10 percent or less in one or two models. The results imply that farmers' livelihood risks are significantly influenced by their assets for agricultural output as a source of income.

The findings show that farmers' human, physical, and natural assets are crucial in determining their exposure to the market, technical, and policy risks, particularly for Chinese farm owners. Growing pressures on Pakistani producers stem from their social, physical, and financial assets. These assets are essential for policy, information, and technological risk. In other words, if improved, these assets would make farmers less sensitive to market, technical, natural, and policy risks. On the other hand, the estimated coefficients of natural assets are consistently positive and statistically significant, implying that greater natural asset endowments would expose farmers to more significant livelihood risks, primarily natural and market risks and government policies and regulations. The natural, financial, social, human, and physical assets may reduce physical and natural risks for growers, and the more vigorous a grower's ability to control physical and natural risks, the more probable it is that the farmer will be exposed to technology and information risks and potential consequences.

TABLE 7 Growers' livelihood assets impacts on livelihood risks in China vs Pakistan.

Context	China										Pakistan									
Indicators type	**NA**		**FA**		**PA**		**SA**		**HA**		**NA**		**FA**		**PA**		**SA**		**HA**	
	B	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**
Constant	0.74*	0.27	0.11**	0.31	0.49**	0.27	0.16*	0.245	0.93***	0.30	0.41*	0.28	0.58**	0.29	0.54**	0.31	0.79*	0.18	0.27*	0.27
Natural risk	−0.05	0.31	−0.52*	0.33	−0.20	0.32	0.35	0.303	−0.55	0.33	0.11	0.42	−0.36	0.44	0.14	0.47	−0.14	0.36	−0.79**	0.45
Market risk	−0.21	0.32	−0.29	0.35	−0.11	0.34	-0.94*	0.33	−0.83*	0.36	−0.84*	0.45	0.08	0.47	−0.54*	0.54	−0.14	0.39	−0.76*	0.50
Technology risk	−0.75**	0.28	−0.49*	0.29	−0.18	0.29	−0.24	0.27	−0.3	0.29	−0.52*	0.35	-0.02*	0.37	−0.12	0.39	−0.66*	0.30	−0.07	0.37
Information risk	−1.04*	0.3	−0.04	0.31	0.52**	0.31	−0.68*	0.297	0.15	0.31	−0.20	0.41	−0.50	0.42	0.60	0.47	0.30	0.35	0.40	0.45
Policy risk	0.03	0.32	−0.47	0.34	−0.80*	0.35	0.54**	0.319	0.03	0.33	−0.17*	0.44	−0.63	0.46	−0.90*	0.50	−0.27	0.39	−0.34	0.48
Model summary																				
Log-likelihood	*378.447*		*347.811*		*359.729*		*395.695*		*353.607*		*260.478*		*244.951*		*225.676*		*375.259*		*246.831*	
Cox and Snell R^2	0.106		*0.069*		*0.034*		*0.056*		*0.069*		0.160		*0.110*		*0.102*		*0.042*		*0.076*	
Prob > chi²	7.875		12.086		11.050		*8.421*		*5.972*		7.557		11.584		26.492		*6.746*		*2.966*	
Pseudo R^2	*0.146*		*0.101*		*0.049*		*0.077*		*0.100*		*0.243*		*0.178*		*0.174*		*0.057*		*0.125*	

NA = natural assets; FA = financial assets; PA = physical assets; SA = social assets; HA = human assets and B = beta coefficient; and S.E = standard error (sig at the ** 0.01 and * 0.05 levels).

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TABLE 8 Growers' livelihood assets' impacts on livelihood strategies.

Context	China										Pakistan									
Indicator type	**NA**		**FA**		**PA**		**SA**		**HA**		**NA**		**FA**		**PA**		**SA**		**HA**	
	B	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**	**B**	**S.E.**
Constant	0.72**	0.20	0.96*	0.21	0.47*	0.23	0.78*	0.20	0.98**	0.22	0.84*	0.28	0.58*	0.35	0.17*	0.317	0.87*	0.22	2.71	0.35
Crop variety adjustment	0.93**	0.30	0.32	0.29	−0.16	0.29	0.14	0.27	0.25	0.30	0.14	0.33	−0.22	0.35	−0.15	0.358	0.02	0.27	−0.04	0.36
Water/fertilizer management	0.03	0.32	0.08	0.34	0.17	0.34	0.32	0.32	0.11**	0.41	−0.15	0.30	−0.16	0.34	0.21	0.35	−0.67*	0.26	0.03	0.35
Agricultural finance	0.10	0.29	−0.08	0.31	-0.41	0.30	−0.37	0.28	−0.03	0.31	−0.01*	0.38	−0.65*	0.43	−0.81*	0.425	−0.37*	0.32	−0.28*	0.43
Agrotechnical support	−0.26	0.27	0.26	0.29	−0.55*	0.28	−0.41*	0.26	−0.24	0.29	−0.11	0.33	−0.33*	0.35	−0.18*	0.368	−0.26*	0.28	0.04**	0.36
Agricultural engineering	−0.49*	0.28	−0.15	0.29	0.08	0.30	0.07	0.28	0.25	0.31	−0.15	0.34	0.28**	0.37	−0.07**	0.383	0.08	0.30	−0.37*	0.38
Off-farm production	−0.59	*0.26	−0.30	0.28	−0.50*	0.27	−0.23	0.26	−0.78*	0.27	0.00	0.32	−0.05	0.34	−0.10	0.351	0.19	0.27	−0.76*	0.34
Model summary																				
Log-likelihood	391.752		367.153		357.834		405.200		356.273		294.728		248.675		247.673		376.598		240.577	
Cox and Snell R^2	0.068		0.011		0.039		0.028		0.061		0.055		0.099		0.032		0.038		0.096	
Prob > chi²	2.132		4.966		7.956		4.937		3.098		7.358		15.580		11.353		6.427		4.461	
Pseudo R^2	0.093		0.016		0.057		0.038		0.088		0.083		0.160		0.054		0.051		0.158	

NA = natural assets; FA = financial assets; PA = physical assets; SA = social assets; HA = human assets and B=beta coefficient; and S.E = standard error (sig at the ** 0.01 and * 0.05 levels).

Furthermore, financial, physical, and social assets assist farmers in Pakistan in coping with climate risks that threaten their way of life and livelihood. Chinese farmers' agricultural productivity is significantly influenced by their social, natural, and human advantages instead of other countries' agricultural products. So, the sensitivity to agricultural risk is correlated with the natural, social, and human assets negatively, with risks associated with policies and information. Pakistani farmers are more sensitive to natural, market, technological, knowledge, and policy risks than their counterparts in China, whose financial, physical, and social assets are substantially greater.

Growers' nexus between livelihood strategies and livelihood assets

The logistic regression findings in Table 8 show that the tested model has passed at least a 5% significance level in both country models. Our estimated results confirmed that all five types of livelihood assets accepted the significance test in at least two of the models, indicating that farmers' adoption of adaptation practices impacted their overall balance of livelihood asset endowments in China vs Pakistan. Moreover, 80% of farmers in China showed water/fertilizer management practice, and approximately 67% of farm owners experienced crop variety adjustment strategies in Pakistan adopted on their farms. In contrast, about 70% of Chinese growers practiced agricultural finance, engineering, and off-farm production as their adaptation strategies. The crop variety adjustment performance was relatively weak, exposed to Chinese farm owners. Consequently, Pakistani landowners show that 65% of off-farm production is the second coping risk adaptation strategy with 62%, 60%, and 58%, followed by agricultural engineering, agrotechnical support, and agricultural finance, respectively, shown in Table 6.

A few factors influencing agricultural production stand out in the model simulations; for example, the estimated coefficients of social assets are positive and statistically significant at the 5% level. The mean function shows that increased human assets positively correlate with market risk. In contrast, natural and social assets positively related with technology and information risks in the Chinese context. In the context of Pakistani farmers, natural, financial, physical, and social assets have a significant positive relationship with policy, technological, and market risks, respectively. It has been shown that all risk management practices are essential in farm production; this may assist growers in employing adaptation techniques and coping with livelihood risks. Surprisingly, the natural, physical, and financial assets findings show a significant positive connection with crop variety adjustment in Chinese growers' approaches and strategies to enhance agricultural production.

Natural assets, in general, have a positive influence on farmers' adaptation techniques. This is mainly for crop variety modification, agricultural financing, and agrotechnical assistance measures. The findings indicate that improving physical, social, and human assets may assist farmers in developing more effective solutions for coping with livelihood risks, such as crop variety modification, water/fertilizer management, agricultural engineering, and off-farm production in the Chinese growers' environment. Furthermore, financial assets play a crucial role in adopting agricultural finance, agrotechnical support, and agricultural engineering approaches. On the other hand, social and human assets negatively impact farmers' adoption of adaptation techniques, particularly those involving water and fertilizer management, agricultural finance, off-farm production, and agriculture technology among Pakistani producers.

Discussion

Because farm probability risks and asset allocation are changing exponentially over time, it is vital to evaluate how different risk management techniques might aid farmers in adjusting to climate change. Farmers often vary in the degree to which they accept risk and are exposed to various hazards in their agricultural products due to their restricted exposure to assets, capital, and other resources.

According to the study results, the natural and policy risks are Pakistani farmers' most crucial livelihood risks. In contrast, Chinese producers' most significant farm risks are technology and information risks, whereas the farmers' natural, physical, social, and human assets in China can protect their livelihoods from the risks associated with crop productivity, and other researchers have made identical findings (Kuang et al., 2020; Sargani et al., 2022). Although farmers' financial, physical, and social assets in Pakistan can shelter their livelihoods from the risks associated with farm production, as indicated by (García de Jalón et al., 2018; Sargani et al., 2022), farmers may boost their livelihood by using physical assets such as irrigation and fertilizer.

In Pakistan, human, physical, social, and financial assets revealed positive significance, but physical, human, and social assets negatively affect farm production in China. Farmers in Pakistan have benefited significantly from natural, physical, social, and human assets, while Chinese farmers have benefited considerably from physical and financial assets. According to the findings, farmers' ability to implement adaptation tactics might be aided by an increase in social and physical assets (Kuang et al., 2020; Sargani et al., 2022). Despite the human, social, and natural assets of Chinese growers and the financial assets of Pakistani farmers, natural assets only have a marginal impact on crop production. This is consistent with current research, which indicates that human assets significantly influence farmers' livelihood risks (Ochieng et al., 2017; Fahad and Wang, 2018; Sargani et al., 2022).

In the same way, farmers in China have adapted agrotechnical support, off-farm production, crop variety adjustment, and agricultural engineering for crop productivity to offset the adverse effects of climate change. In contrast, Pakistani farmers have adapted agricultural financing, fertilizer/water management, and crop variety adaptation to address livelihood concerns and increase agricultural production.

According to the findings, farmers in Pakistan are especially vulnerable to livelihood risks such as market, technological, and policy risks due to a lack of qualified human capital in their communities (Sargani et al., 2022). Meanwhile, the process of the human asset broadens farmers' expertise. It increases their awareness of their livelihood risks while enhancing their capacity to obtain and use information to manage such risks with better farm practices (Li et al., 2017b; Wu et al., 2017). Natural risks and market fluctuations mainly cause agricultural livelihood risks. The production and price of crops are the two most problematic elements from a farmers' standpoint; helping farmers manage agrarian input costs, stable market prices, and a smooth marketing route allow farmers to continue farming (Ma and Abdulai, 2016).

Surprisingly, the financial and social assets findings are the same, indicating that farmers with little economic or social resources find it difficult to deal with threats to their livelihood. The results of this study are consistent with those of Ochieng et al. (2017), Sargani et al. (2022), and Fahad and Wang (2018), showing that a lack of financial assets (for example, loan options) exposes farmers to risks and causes them to become vulnerable to risking their livelihood. Furthermore, advances in social assets may aid farmers in overcoming cognitive, normative, and institutional constraints, hence reducing livelihood risks (Jones and Boyd, 2011; García de Jalón et al., 2018; Sargani et al., 2021b).

On the other hand, farmers who have substantial natural assets are more likely to be subjected to livelihood risks, including natural disasters, market fluctuations, and policy changes. One probable reason is that farmers rely on natural resources to produce agricultural output. In many cases, farmers' attitudes toward risk are tied to the farmer's financial capacity to absorb a modest gain or loss (Sargani et al., 2020, 2022). As a result, agricultural production, on the other hand, is very vulnerable to changes in the climate (Jianjun et al., 2015; Alam et al., 2016; Sargani et al., 2020). As a result, farmers are more sensitive to policy and market risks when they have insecurity about the land tenure system. Combined with a scarcity of market access, farmers further reduce productivity and development (Fahad and Wang, 2018; Sargani et al., 2022). Similarly, our results indicate that the more significant the amount of physical assets, the greater the likelihood that the farmers would be susceptible to technological and information risks. These discoveries defy conventional thinking since more tremendous physical assets are frequently connected with advanced technology and richer infrastructure.

Farmers are more likely to take on debts that must be repaid, and they lack the leisure money to cope with livelihood risks. However, this is possible since various accessible lending facilities have been developed to encourage purchasing new agricultural equipment, increase agricultural production efficiency, and strengthen farmers' physical assets.

Furthermore, the efficient functioning of sophisticated agricultural equipment often necessitates the engagement of specialized personnel. Previous research has shown that Chinese farmers are often overlooked for agrarian extension services (Chen et al., 2014; Zhai et al., 2018). Farm records and off-farm facts and figures, information from input dealers, vendors, resource persons, other farmers, and market prices have made small-scale farmers in Pakistan more vulnerable to climate change because they do not have enough information regarding climatic variabilities. Our data indicate that most farmers have used at least one adaptation approach to mitigate livelihood risks, depending on their available assets. The results, in particular, imply that an increase in social assets may help farmers adopt adaptation approaches that are in line with prior findings (Jones and Boyd, 2011; García de Jalón et al., 2018; Kuang et al., 2020; Sargani et al., 2022) Investing in social support such as access to information, agricultural organizations, and networks not only helps farmers overcome social barriers but also helps farmers get a better understanding of methods and execute adaptation approaches.

Interestingly, data show that farmers with more valuable natural assets are more inclined to participate in agricultural production and are more prepared to use adaptation mechanisms in the face of high-risk agriculture. This favorable impact of natural assets is consistent with previous research (Cao et al., 2009; Jianjun et al., 2015; Khanal et al., 2018b; Sargani et al., 2022). In addition, these results proved that physical assets are a critical component for farm owners to maximize water and fertilizer use. Furthermore, research by García de Jalón et al. (2018) also demonstrated that physical assets are vital for optimizing water and fertilizer usage for farm owners.

In addition, the statistics reveals that financial assets are important in assisting farmers in adopting agricultural finance and agricultural engineering practices and technology. Another possible reason is that new adaptation methods, such as agrarian finance and agricultural engineering, which are more expensive to implement than standard adaption techniques, need more investment (Chen et al., 2014). These findings (Bryan et al., 2009; García de Jalón et al., 2018; Kuang et al., 2020) indicate that more vital farmers are more likely to use climate change adaptation measures. In contrast, the research (Waseem et al., 2020; Sargani et al., 2022) emphasized the relevance of socio-economic and psychological factors in encouraging sustainable agriculture practices in Pakistan. In addition, the statistics reveals that financial assets are important in assisting farmers in adopting agricultural finance and agricultural engineering practices and technology (Alam et al., 2016; Khanal et al., 2018b). However (Asfaw et al., 2019), research shows that diversity's effect on family income varies by country and diversification strategy. Yet another possible explanation, when combined with outfield inquests, is that effectively, human economic, physical, natural, and social assets empower farm owners to improve their adaptation strategies (e.g., off-farm operations) to attain their livelihoods standard based on priorities to gain more profitability in each country.

Conclusion

This cross-border analysis showed that farmers' exposure to farm risks is significantly influenced by their allocation of livelihood assets in response to climate change comparatively among Chinese and Pakistani farmers, using an integrative analytical approach. Farmers' five livelihood assets were measured in this research, and we investigated the impact of each type of capital asset on farmers' farm risk attitudes in climate change adaptation practices. Because the agricultural sector provides an opportunity to contribute toward climate change mitigation and leads the transformation process in achieving SDG. A quantitative index principal component analysis setting for livelihood assets was constructed based on the framework for sustainable livelihoods and farmers' livelihood assets to examine how farmers perceive risk and implement an adaptive approach. The paper looked at how farmers' livelihood assets affected their exposure to livelihood risks, adaptation measures, and ways to mitigate climate change risks in developing countries, mainly Chinese and Pakistani farm owners.

According to the study results, natural and market risks pose the greatest threat to Pakistani farmers' livelihoods. In addition to agrochemical aid, diverse crop selection choices, irrigation and fertilizers management, agricultural financing, and agrotechnical support are essential adaptation practices used by farmers in China.

Our research shows that livelihood assets help farmers avoid possible livelihood risks linked with agricultural production and help them establish appropriate adaptation strategies to cope with such threats.

Specifically, social, financial, and human assets mitigate the risks to Pakistani farmers' livelihoods, including market, technical, and policy hazards. This research suggests that intangible assets, such as social networks and financial help, may be more critical to addressing livelihood-resilient cultivars for crop production.

Additionally, farmers are more likely to use adaptation practices because they have access to land, agricultural equipment, and social networks, facilitating their decision. Therefore, except for human assets, practically, all the other four livelihood assets positively influence farmers' adaptation measures in China.

When significant results are found, more studies are required. First and foremost, we cannot overlook that farmers face various risks to their livelihood, each variable influencing agricultural production. Researchers examine if and how farmers are exposed to livelihood risks and how they react, to better understand the role of livelihood assets in this exposure and adopting adaptive mechanisms.

Additionally, the benefits farmers gain from adopting an adaptation strategy may assist farmers in mitigating the negative consequences of a particular livelihood risk and improve the value of a specific asset of livelihood.

Farm owners in impoverished countries are especially vulnerable to climate change. Because there are not enough assets or funds for farm subsidies, most of them depend on traditional methods to mitigate the detrimental effects of these risks on agricultural productivity. As a result, the government should develop a long-term plan to subsidize local farmers *via* direct payments for farm equipment and expanded agricultural extension services.

Thus, there is a need to conduct a socio-environmentally complete assessment of livelihood asset allocation. This research examines the relationship between livelihood assets and livelihood risks and between livelihood assets and adaptation strategies. The investigation should investigate how the risk associated with livelihood assets might be adjusted in productive ways. Finally, there is a delicate interaction between livelihood assets, risk, and adaptation strategy.

This study creates an index that uses principles from the sustainable livelihoods framework to distinguish the many characteristics of poverty. Furthermore, this index considers asset endowments, including the value of networks and connections and social inclusion and accessibility commonly overlooked in conventional assessments. The sustainable livelihoods index (SLI) quantifies the combination of livelihood assets that govern individual livelihood strategies, allowing for a more nuanced depiction of poverty's uncertain nature. As a result, the potential for effectively targeting sustainable development initiatives by both the government and development aid venture capitals may increase farm production and yield. Similarly, knowing which processes and new networks are involved in climate stress response is essential for guiding future decisions on which cultivars are the most suited and robust for crop production practices. This is particularly noteworthy in regions where human–environment interactions substantially impact the food system and livelihoods' sustainability of agricultural societies.

Policy implications

Moreover, the study's results have several significant policy implications for the beginning. The findings imply that social and financial assets may assist farmers in managing their livelihood risks and adapting to climate change. Thus, governmental interventions should prioritize the development of a physical network, financial aid, and loans to farmers by overcoming the dependency between livelihoods and environmental conditions, which can eliminate poverty and bring better rural living.

We discovered that although human assets may assist farmers in avoiding livelihood risks, they negatively impact their capacity to adapt to changing environments. According to the findings, increasing farmers' human capital may assist farm owners in better managing the risks associated with their livelihoods—off-farm business relocation methods. Farmers with distinctive natural or physical assets are more exposed to livelihood threats and are more likely to use adaptation strategies.

Although essential discoveries show that farmers face various livelihood risks, which affect agricultural production to varying degrees, governmental interventions should attempt to create social networks and give financial aid and credits to help farmers improve their livelihoods. This may speed up farmer migration to off-farm agriculture adoption. Therefore, the government should offer a long-term program to enhance direct payments for agricultural machines and improve extension services in agriculture to encourage local farmers to adopt adaption tactics.

Government e-services are excellent for high agricultural production. Both countries may need national digital agrarian strategies. This can be carried out by including the agri-food sector in national digital initiatives that aim to revolutionize the agri-industry and society. Digital transformation will alter labor markets and farm businesses in the agri-food sector. Both governments must support "digital start-ups" in agriculture and farm businesses.

However, we are more concerned about whether farmers are exposed to livelihood risks and implementation of adaptation strategies to discover the significance of livelihood assets. Farmers who implement an adaptation plan may reduce the negative consequences of a livelihood risk and raise a livelihood asset to cope with climate change and adaptive attitudes, and potential practices can be introduced in both studied areas with the measures needed to reduce the climate's impact on farm business.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving human participants were reviewed and approved by College of Economics Sichuan Agricultural University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

GRS: data curation and software. GRS, AAC and YL: formal analysis, YJ: validation. GRS, YL, and HZ: investigation, writing—review, and editing. GRS, HZ, and YJ: resources, visualization, and supervision. GRS, HZ, AAC and YL: data entry. All authors have read and approved the final version of the manuscript.

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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.

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