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**The Resilience Paradox: A Climate Change Coping Mechanism in the Farm Households from
Samarkand Region of Uzbekistan**

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Abstract

The climate change literature broadly characterizes resilience as the capacity of the household to withstand the negative consequences of climate change. However, most studies on climate change resilience use a general or inconclusive relationship between resilience and the coping strategy of the household. To extend the existing literature, we applied FAO's Resilience Index Measurement Analysis (RIMA) approach to construct the Resilience Capacity Index (RCI). Using Latent Class Analysis (LCA), we cluster homogenous classes describing household coping strategy behavior. With an Instrumental Approach (IA), we explore how climate change resilience changes the perception of coping strategies. Our findings generally conclude that there is a negative relationship between long-term RCI and short-term household coping strategies. This relationship is particularly significant for changing planting dates, planting short-cycle crop varieties, crop diversification, and tree planting. We can conclude that climate change resilience may diminish the motivation to activate short-term coping strategies for policy interventions.

Key words: Climate change, Resilience, Household Capacity, Agriculture, Latent Class Analysis (LCA)

Introduction

The adverse consequences of global warming and climate change have intensified and become more evident in the last decades, with particular effects on agriculture, human activities, and the socio-economic livelihoods of world societies. In particular, developing countries are more vulnerable and less resilient to climate extremes despite their lower share of annual global carbon emissions (Ali & Erenstein, 2017; Maskrey, Buescher, Peduzzi, & Schaerpf, 2007). Due to recent climate-related events such as floods and droughts occurring across the globe, billions of world rural inhabitants are becoming more food insecure and sensitive to food price fluctuations (Dasgupta & Robinson, 2022).

Additionally, it is predicted that climate change may lead to a noticeable increase on average in the number of malnourished children in developing countries by 2050 (Ebi, 2008; Lieber, Chin-Hong, Kelly, Dandu, & Weiser, 2022; Muttarak, 2019). Along with this, frequent droughts and increase in warming caused by climate change have intensively accelerated the glacier melting, posing water scarcities and damaging crop production in arid zones of the continent like Central Asia (Li, Fang, Chen, Duan, & Mukanov, 2020; Vinke et al., 2017). For this reason, improving resilience and coping strategies is vital as a policy response to climate change in developing nations. As per a recent study by Egamberdiev, Bobojonov, Kuhn, Glaubien, and Akramov (2024), farmers with a higher resilience capacity can mediate climate-driven hazards and ensure food security in Central Asia. However, there is still a shortage to apply the concept of resilience as a strong political agenda in the environmental science (Mostafavi, Fiocchi, Dellacasa, & Hoque, 2022).

Central Asian countries are particularly vulnerable to climate-related hazards because of their arid geography and higher level of dependency on agricultural production (Babakholov, Bobojonov, Hasanov, & Glaubien, 2022; Lioubimtseva & Henebry, 2009). The region has a sharply continental climate with high variability levels, ranging from arid to semi-arid on both temporal and spatial scales (Gupta et al., 2009). The agricultural sector still plays an essential role for the national economies of Central Asian countries, which responsible for 10-50% of employment and 20-45% of GDP (Babakholov et al., 2022; Bobojonov, Berg, Franz-Vasdeki, Martius, & Lamers, 2016; Karatayev, Clarke, Salnikov, Bekseitova, & Nizamova, 2022). Several studies have argued that the impact of climate change and global warming, with its specific implications for the agricultural sector in Central Asia, remains an important research question. Climate change in Central Asian countries, among others, manifests itself in temperature increases, rainfall reduction in the arid plains, and, last but not least, accelerated glacial melt (Reyer et al., 2017).

First of all, this paper contributes to filling the theoretical and empirical gaps of climate change resilience, particularly in farm households of Uzbekistan. This paper uses resilience capacity to signify farm resilience to shocks and stresses triggered by climate changes. Therefore, this study selects the perspectives of farm households to conceptualize how resilience capacity affects the coping strategy to climate changes from the Samarkand region of Uzbekistan. In this paper, we use the term resilience to represent household resilience capacity, indicating the ability to withstand shocks and stresses that should not have long-lasting adverse effects on household livelihood. Since resilience is a latent and multidisciplinary phenomenon, we use Resilience Index Measurement and Analysis—II by FAO (2016). As for coping strategies, we refer to household activities as ex-ante (whereby the household prepared for the future shock) or ex-post (whereby the household used for a current or past shock) in farm operations.

Literature Review

Resilience is the persistence of systems to absorb change and disturbance (Holling & systematics, 1973); therefore, it represents the ability to withstand and recover from shocks (Klein, Nicholls, & Thomalla, 2003). The most recent conceptual frameworks have acknowledged that resilience represents adaptive, absorptive, and transformative capacities (Ansah, Gardebroek, & Ihle, 2019; Béné, Wood, Newsham, & Davies, 2012; Davoudi, Brooks, & Mehmood, 2013) which is particularly important for dealing with the changes in climate and ecosystems (Adger et al., 2011). One of the prominent definitions indicates that resilience is “...the ability to prevent disasters and crises as well as to anticipate, absorb, accommodate or recover from them in a timely, efficient and sustainable manner”.

In the context of farm operations, quantifying resilience as a capacity index is challenging due to the wide range of operations incurred in farm management (Slijper, de Mey, Poortvliet, & Meuwissen, 2022; Taghipoor et al., 2023). As for the operationalization of resilience towards specific development outcomes, different properties should be taken into account for the measurement. The nature of multifaceted status explains the first important property. In this case, the construction should have different dimensions depending on the nature of resilience (Constas, Frankenberger, & Hoddinott, 2014). Another important property is related to a latent construct. Since resilience is not observable, treating resilience variable as latent should be constructed through different observed variables (d’Errico, Garbero, Constas, & series, 2016). Finally, d’Errico et al. (2016) provide a focal point, making the resilience a capacity index showing different capacity-based functions between individual, household, or community levels. According to one of the dominating resilience frameworks, resilience as capacity should characterize absorptive capacity (persistency), adaptive capacity (incremental adjustment), and transformative capacity (transformational actions) (Béné et al., 2012). Therefore, the operationalization of resilience as a measurement strategy should be based on multidimensional, latent, and capacity-based variable.

Climate change adaptation representing discrete actions is a cornerstone of household responses to ameliorate the negative impacts of climate change. Therefore, the adaptation is implemented by the households ‘...to maintain and increase resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change (Agard et al., 2014). It is particularly important for farm operations because adaptation strategies in response to climate variability are pronouncedly recognized to increase resilience (Karimi, Karami, & Keshavarz, 2018; McEvoy, Fünfgeld, & Bosomworth, 2013; Muricho, Otieno, Oluoch-Kosura, & Jirström, 2019).

Data and Methodology

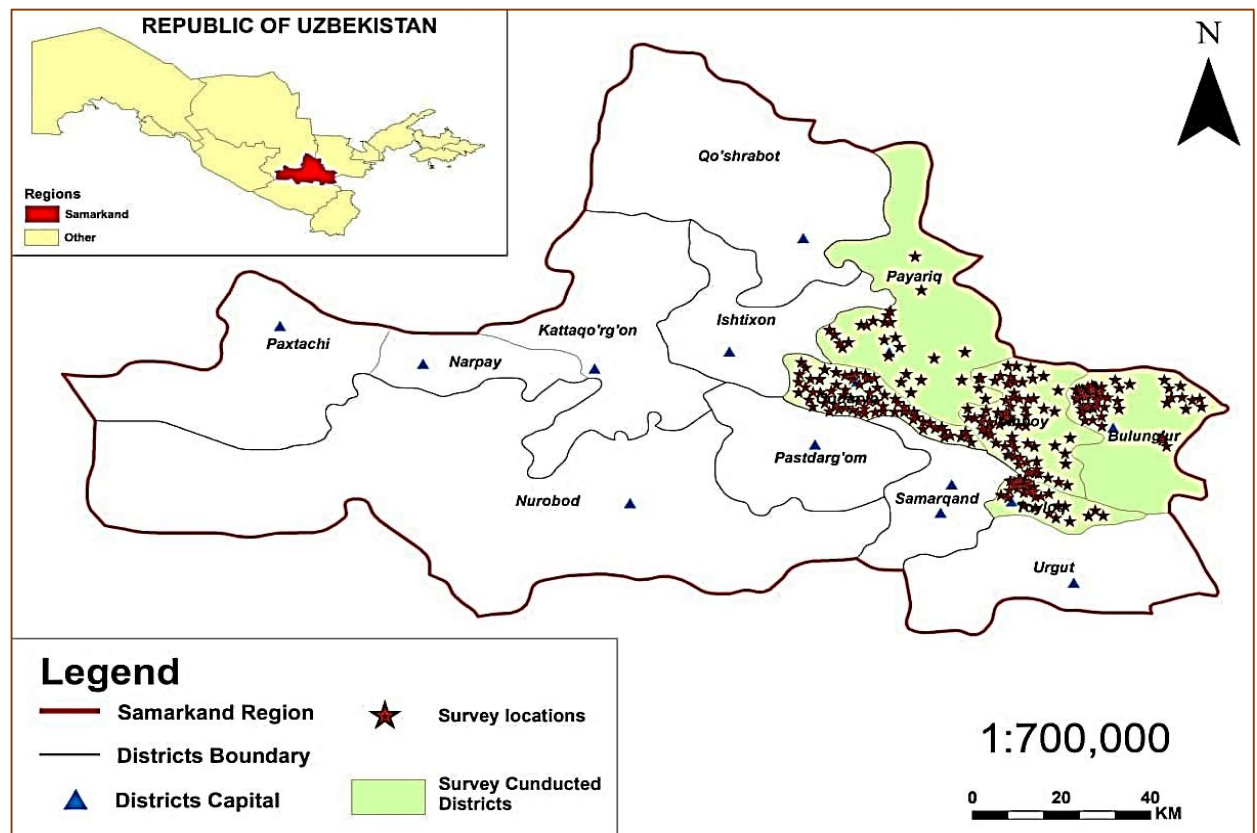
Data

The data was obtained from the farmers operating in the Samarkand region districts, located in the upstream zone of the Zarafshan River basin with sufficient water. A total of 307 commercialized farm households were interviewed by experienced enumerators utilizing a multi-stage sampling technique from March to April 2021. Initially, surveyed villages/communities from each district were stratified based on farm households' production type and demography. Then, large-scale farm households mostly engaged in cash crop growing were randomly sampled from each village and interviewed face-to-face following their outcomes. The number of surveyed samples from each district represents roughly about 15 percent of the total farmers (Table-1).

Table-1. The total number of farmers and surveyed farm households in the study area

	Districts				
	Bulungur	Djambai	Taylok	Akdarya	Paiarik
The total number of farmers	451	1215	831	1592	615
The total number of farmers surveyed	62	72	83	42	48

The Samarkand province is located in the central-eastern part of the country, as shown in Map-1. The Samarkand province was chosen for the analysis because it is one of the leading provinces in terms of agricultural production, which provides roughly 14% of the total GDP of the Republic of Uzbekistan (Babakholov et al., 2022; Djuraeva, Bobojonov, Kuhn, & Glauben, 2023).



Map-1. Map of the surveyed areas

Latent Profile Analysis

LPA, a finite mixture models, clusters population heterogeneity into homogenous characteristics. Therefore, this method is referred to as a person-centered rather than a traditional variable-centered approach (Bergman, Magnusson, & psychopathology, 1997). Although LPA is particularly used in many psychological studies, it is useful to create topologies and profiles to explain the perception of individuals toward adaptive strategies. Therefore, LPA in development studies has become a plausible methodology for working with varying dimensions of phenomenon dealing with the problem of heterogeneity (Lanza & Cooper, 2016). The approach to predict latent classes (class membership) is realized through the improved three-step methodology (Bolck, Croon, & Hageaars, 2004; Collier & Leite, 2017; Vermunt, 2017). According to the authors, this approach includes the standardized steps to model a latent profile with covariates: (1) estimating a standard model without including any covariate; (2) assigning observers to the profiles; (3) estimate the regression to estimate the relationship between covariates and latent profiles.

The density function of the latent model for the profiles is expressed as:

$$f(\chi_i/\theta) = \sum_{k=1}^K \pi_k f_k(x_i/\theta_k) \quad 1$$

For observed x_i ($i = 1, \dots, n$) variables, $f_k(x_i/\theta_k)$ is a profile-specific normal density function under the mean vector and covariance matrix $\theta_k = (\mu_k, \Sigma_k)$.

The posterior distribution of latent profiles is obtained by:

$$p(x/\eta) = p(x/\eta) \cdot p(\eta) / \sum_{\eta=1}^K p(x/\eta) \cdot p(\eta) \quad 2$$

where η shows the latent profile variable.

In order to obtain latent categorical variables, we regressed the estimated class membership on the auxiliary variables in the third stage.

$$P(\eta = \frac{k}{Z_i}) = \frac{\exp(\gamma_{0k} + \sum_{q=1}^Q \gamma_{qk} Z_{iq})}{\sum_{s=1}^K \exp(\gamma_{0s} + \sum_{q=1}^Q \gamma_{qs} Z_{iq})} \quad 3$$

where Z_{iq} represents one of the Q covariates, and Z_i is the covariate vector for individual i . For the latent class membership η , the parameters are γ_{qk} for $0 \leq q \leq Q$.

The measurement of household resilience towards climate change is complex since the resilience itself is a multidimensional and latent variable. According to RIMA-II methodology, the estimation of resilience capacity index (RCI) is based on different pillars (determinants) that are multidimensional and unobservable.

Estimation Strategy

We propose to apply the IV approach by accounting for the forms of bias explained above. In this case, we use a 2 Stage Least Squares (2SLS) IV approach by following different estimations criterion.

$$y_h = y_h\beta_1 + x_{1h}\beta_2 + u_h \quad 4$$

$$y_h = x_{1h}\Pi_1 + x_{2h}\Pi_2 + v_h \quad 5$$

In Equations 5 and 6, y_h is dependent variable or adoption perceptions for the h th household while y_h is endogenous regressor which is RCI. The remaining x_1 and x_2 variables represent the included and excluded exogenous regressors, respectively. By assuming nonzero correlations, we define u_h and v_h as zero-mean error terms. For the exclusion criteria, the distance variables have already become a good proxy to explain household resilience (Egamberdiev, Bobojonov, Kuhn, & Glauben, 2023; Egamberdiev et al., 2024; Jones, 2019; Mekuyie, Jordaan, & Melka, 2018; Melketo et al., 2021; Ngoma, Finn, & Kabisa; Wang et al., 2021). It is particularly important for rural areas of Central Asia, where households activate informal networking in the close neighbourhoods for strengthening resilience (Egamberdiev, 2024).

Findings

Latent Profiles

We have two different profiles based on response patterns from nine coping strategies (Figure-1). We labelled Profile-1 as “Low Climate Change Adaptation” due to a lower level of predictive mean score. In this profile, the actions that households took are more on water management, changing planting date, and crop rotation. The following actions for adaptive strategies are nutrient management and crop diversification. Although Item-1 (water management) and Item-3 (Soil conversation) have the lowest predictive mean score, other items appear with higher item-response probabilities than Profile-1 or the “Low Climate Change Adaptation” profile. Therefore, we labelled this as “High Climate Change Adaptation” profile.

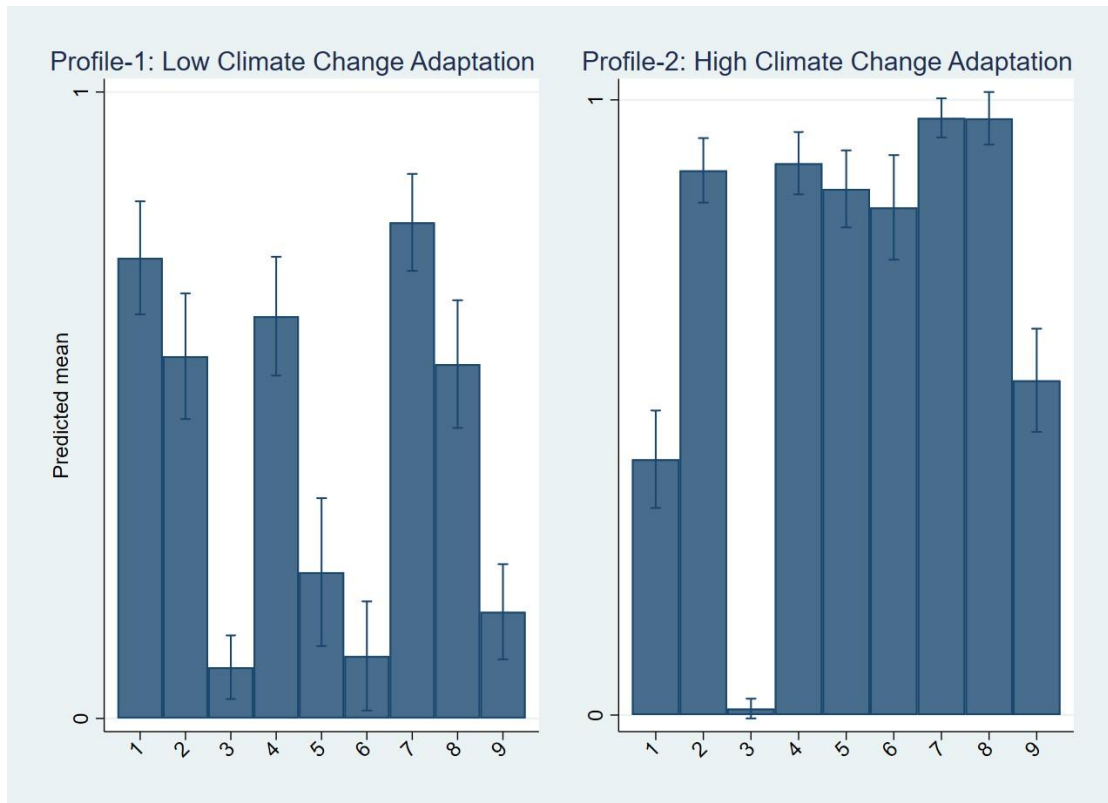


Fig.1 Latent Profiles for Coping Strategies

Note: 1-Water management; 2-Nutrient management; 3-Soil conversation; 4-Changing planting dates; 5-Improved crop varieties; 6-Planting short cycle crop varieties; 7-Crop rotation; 8-Crop diversification; and 9-Tree planting

Resilience and Coping Strategies

A negative effect of resilience capacity on the perception of climate change mitigation might be due to experiencing higher shocks or stress due to low resilience levels in the household (Mah, Chapman, Markowitz, & Lickel, 2020). Similarly, Archer (2016) found that resilient households are less likely to suffer from exposure to climate change. It makes an apparent trade-off between short-term coping strategies for climate change and long-term resilience, particularly household adaptive capacity (Brockhaus, Djoudi, & Locatelli, 2013). Therefore, household response to climate change by activating coping strategies might be at the cost of decreasing the precondition of the households, reflecting the determinants (pillars) of the resilience itself (Béné et al., 2012). It is particularly true that Central Asian countries experience covariant and idiosyncratic shocks, where resilience as capacity has a mitigating role when shocks intensify (Egamberdiev et al., 2023).

Table-3. Regression results

	2SLS	OLS
RCI	-2.023** (1.011)	0.833 (0.958)
Age	0.001 (0.002)	0.012 (0.012)
Higher education	0.130* (0.075)	0.205 (0.276)
Family size	0.025 (0.016)	0.035 (0.063)
High salinity	-0.062 (0.158)	-0.283 (0.675)
Oqdaryo	0.231 (0.313)	-1.858*** (0.488)
Payariq	-0.229 (0.186)	-2.571*** (0.497)
Toyloq	-0.012 (0.102)	-2.44 (0.438)
Jomboy	0.118 (0.100)	0.036 (0.384)
Const.	1.930*** (0.228)	0.130 (0.657)
Observation	307	307
Cragg-Donald F Statistic	15.046	

Note: *p < 0.10; **p < 0.05; ***P < 0.001; Standard errors in parentheses. Bulungur region is a reference variable to Oqdaryo, Payariq, Toyloq and Jomboy regions.

Here, we want to see whether RCI affects each coping strategy. Therefore, models represent coping strategies. It is significant in Model-4: Changing planting date; Model-6: Planting short cycle crop varieties; Model-8: Crop Diversification; and Model-9: Planting trees. The significance of the mentioned outcomes has already been accentuated by other findings indicating coping and adapting strategies to climate change in communities (Kihila, 2018). Particularly, Fedele et al. (2016) mentioned that the intervention through increasing the number of trees in the community is the solution to supporting resilience or decreasing climate change vulnerabilities. In addition, crop diversification is also considered one of the potentially promising solutions to implement climate change resilience (Birthal & Hazrana, 2019; Labeyrie et al., 2021; Makate, Wang, Makate, & Mango, 2016; Ochieng et al., 2020; Roesch-McNally, Arbuckle, & Tyndall, 2018; Rustamova, Primov, Karimov, Khaitov, & Karimov, 2023; Vernoooy, 2022).

Table-3. Regression results

	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8	Model-9
RCI	1.487 (0.977)	-1.131 (0.879)	0.397 (0.366)	-1.696* (0.918)	0.396 (0.848)	-1.753* (1.050)	-0.566 (0.556)	-1.803** (0.800)	-1.868* (1.071)
Age	-0.004 (0.002)	0.001 (0.002)	0.001 (0.001)	0.001 (0.002)	-0.001 (0.002)	0.001 (0.002)	0.001 (0.001)	0.002 (0.002)	-0.001 (0.003)
Higher education	-0.030 (0.073)	0.139** (0.065)	0.003 (0.027)	0.086 (0.068)	-0.020 (0.063)	0.126 (0.078)	0.031 (0.041)	0.067 (0.060)	0.093 (0.080)
Family size	-0.001 (0.016)	0.018 (0.014)	-0.012** (0.006)	0.006 (0.015)	0.009 (0.014)	0.017 (0.017)	-0.009 (0.009)	0.014 (0.013)	0.037** (0.017)
High salinity	-0.169 (0.153)	-0.151 (0.137)	-0.093 (0.057)	-0.178 (0.144)	-0.234* (0.133)	0.003 (0.164)	-0.011 (0.087)	0.005 (0.125)	0.037 (0.168)
Oqdaryo	-0.127 (0.302)	0.174 (0.272)	-0.135 (0.113)	0.533* (0.284)	-0.406 (0.262)	0.333 (0.032)	0.123 (0.172)	0.317 (0.247)	0.444 (0.331)
Payariq	-0.001 (0.180)	0.046 (0.162)	0.079 (0.067)	0.330* (0.169)	-0.431*** (0.156)	-0.081 (0.193)	-0.239** (0.102)	-0.340** (0.147)	0.145 (0.197)
Toyloq	-0.079 (0.098)	-0.028 (0.088)	0.015 (0.037)	-0.082 (0.092)	0.007 (0.085)	0.107 (0.106)	-0.135** (0.056)	-0.034 (0.080)	0.046 (0.108)
Jomboy	-0.061 (0.097)	0.105 (0.087)	-0.055 (0.036)	0.082 (0.091)	0.101 (0.084)	0.250** (0.104)	-0.020 (0.055)	0.078 (0.079)	-0.071 (0.106)

Const.	0.361	0.811***	-0.005	1.015***	0.615***	0.757***	1.069***	1.105***	0.618**
	(0.220)	(0.198)	(0.082)	(0.207)	(0.191)	(0.236)	(0.125)	(0.180)	(0.241)
Observation	307	307	307	307	307	307	307	307	307
Cragg-Donald	15.046	15.046	15.046	15.046	15.046	15.046	15.046	15.046	15.046
F Statistic									

Note: *p < 0.10; **p < 0.05; ***P < 0.001; Standard errors in parentheses. Bulungur region is a reference variable to Oqdaryo, Payariq, Toyloq and Jomboy regions.

Conclusion

The purpose of the manuscript is twofold: (i) to understand the main characteristics of household coping strategies and resilience towards climate change, and (ii) the effect of resilience capacity on the climate change coping strategy. We measured the resilience or RCI by using different pillars such as Access to Basic Services (ABS), Assets (AST), Social Safety Nets (SSN), Adaptive Capacity (AC), and Sensitivity (S) under RIMA approach. This measurement will contribute to the understanding of climate vulnerability conceptualization by Nawrotzki, Tebeck, Harten, and Blankenagel (2023). Another significant contribution of this manuscript is to cluster households into homogenous groups to define households with similar characteristics. Using Latent Profile Analysis (LPA), our findings for obtaining a homogenous profile indicate that not all households equally activate coping strategies in the face of shocks.

Analysis of the effect of RCI on climate change mitigation strategies revealed that a higher level of RCI negatively affects climate change mitigations. In other words, more resilient households are less likely to activate mitigating strategies. In other words, more resilient households are less likely to activate mitigating strategies. This is particularly true of the findings on the relationship between RCI and changing planting dates, crop diversification, and planting trees. In the context of climate change coping strategies and mitigating activities, further attempts should not only consider resilience capacity obtained from particularly tangible properties, but there should be the perception based resilience (Ogunbode et al., 2019).

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