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Article

The Role of Livelihood Assets in Affecting Community Adaptive Capacity in Facing Shocks in Karangrejo Village, Indonesia

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Abstract: This study addresses a theoretical gap by examining how multiple livelihood assets collectively enhance rural communities' adaptive capacity and contribute to rural resilience theory. Using structural equation modeling, data were collected from June to August 2024 from 372 randomly selected households in Karangrejo Village, Indonesia, to test whether livelihood assets significantly influence adaptive capacity in response to diverse economic, social, and environmental shocks. The findings reveal that human, natural, physical, and social capital show a strong, positive effect on adaptive capacity, whereas financial capital alone does not significantly enhance resilience. Despite the limited geographic scope, the results underscore that comprehensive asset combinations—rather than reliance on a single form of capital—strengthen a community's capacity to withstand shocks. This integrated perspective suggests that balanced investments across multiple forms of capital foster sustainable and flexible adaptation strategies, enabling communities to navigate uncertainty and maintain stability. The study highlights the critical importance of diversifying livelihood assets to foster long-term rural resilience and improve quality of life, offering practical insights for policymakers, practitioners, and researchers in developing holistic interventions that support adaptive capacity.

Keywords: adaptive capacity; livelihood assets; rural resilience; Karangrejo Village; Indonesia; shocks; structural equation models



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1. Introduction

Rural communities worldwide are increasingly challenged by a broad range of economic, social, and environmental shocks that threaten their stability, well-being, and long-term sustainability. Such shocks may be manifested in fluctuating market conditions, demographic transitions, or environmental hazards like droughts, floods, and other climate-related events. Under these conditions, understanding how communities manage and mobilize their resources to cope with stressors is vital for informing policy interventions, guiding development initiatives, and ensuring that rural livelihoods remain resilient in the face of uncertainty (Li et al., 2017; Seaborn et al., 2021). Contemporary scholarship on resilience has thus shifted toward an integrated perspective, recognizing that communities can only adapt effectively if they have access to a diverse range of livelihood assets. Emerging studies emphasize that resource diversification and synergy—encompassing

human, social, natural, physical, and financial forms of capital—can collectively strengthen adaptive capacity (Scoones, 1998; Aribi & Sghaier, 2020; Liu et al., 2022).

Despite this growing consensus, many existing studies focus narrowly on one or two capital types, such as financial or physical capital, potentially overlooking how multiple assets interact to produce adaptive capacity (Ellis, 2000; Kuipers & de Jong, 2023). The Sustainable Livelihoods Approach (SLA), however, highlights how intangible resources—such as knowledge networks, cultural norms, and institutional supports—significantly influence a community’s resilience (Bebbington, 1999; Nunan, 2017). Empirical work in various rural contexts confirms that communities withstand disruptions more effectively when they can draw on broad asset portfolios and integrate them (Datta & Roy, 2022; Aqib et al., 2024).

Without a holistic lens, it is difficult to gauge how weaknesses in one form of capital might be compensated by strengths in another, or how these capitals work in tandem to bolster resilience (Aribi & Sghaier, 2020). Accordingly, a systems perspective suggests examining the structural relationships among multiple capitals, employing advanced empirical methods such as structural equation modeling (SEM) to identify which forms of capital most strongly affect the adaptive capacity of rural communities (Henseler et al., 2024). This approach can better guide evidence-based policies aimed at encouraging asset diversification and synergy.

Previous studies point to consistent linkages between certain capitals and stronger adaptive capacity. Human capital—education, skills, and health—equips individuals to learn and innovate under changing conditions (Jha & Gupta, 2021; Bitana et al., 2023). Social capital, including trust and networks, enables collective action and efficient resource sharing during crises (Prayitno et al., 2024b; Rahmawati et al., 2024; Liu et al., 2022). Natural capital, such as land and water, forms the ecological basis of many livelihoods (Christina, 2018), while physical capital—ranging from infrastructure to technology—helps communities adapt to and diversify their income streams (Eakin & Luers, 2006; Aqib et al., 2024). By contrast, financial capital alone cannot ensure resilience if other forms of capital remain weak or inaccessible (Moser, 1998; Kasim et al., 2017).

A central aim of this research is to examine how these multiple capitals collectively shape adaptive capacity, addressing the persistent gap in understanding their interactive effects. Specifically, the study applies SEM to identify structural relationships among human, social, natural, physical, and financial assets and tests their combined influence on adaptive capacity in Karangrejo Village, Indonesia.

The remainder of this article is structured as follows: Section 2 presents the literature review and conceptual framework, Section 3 describes the methodology, Section 4 reports the results, and Section 5 offers the discussion. The final section concludes by highlighting key policy implications, research limitations—including the study’s limited geographical scope—and avenues for future inquiry.

2. Literature Review

2.1. Conceptualizing Adaptive Capacity

Adaptive capacity, in the context of social-ecological systems, refers to the ability of communities to adjust behaviors, strategies, and resource allocations in response to disturbances, uncertainties, and opportunities (Adger, 2006; Berkes & Ross, 2013; Folke, 2006). Grounded in resilience theory, adaptive capacity is not viewed as static; rather, it evolves as communities learn, experiment, and reorganize their livelihood strategies in changing conditions (Vallury et al., 2022; Li et al., 2017). This conceptualization aligns with broader frameworks emphasizing the dynamic interplay between social, economic, and

environmental factors in shaping the long-term sustainability of rural communities (Nunan, 2017; Pelling, 2011).

Central to understanding adaptive capacity is the recognition that it emerges through multiple forms of capital, each offering distinct yet interconnected contributions to resilience. By examining how human, social, natural, physical, and financial capital interact and reinforce one another, we gain a more holistic perspective on how communities respond to shocks (Scoones, 1998; Bebbington, 1999; Ellis, 2000). The conceptual model (Figure 1) illustrates five key capitals hypothesized to influence adaptive capacity, informed by the SLA and a wealth of theoretical and empirical studies across disciplines.

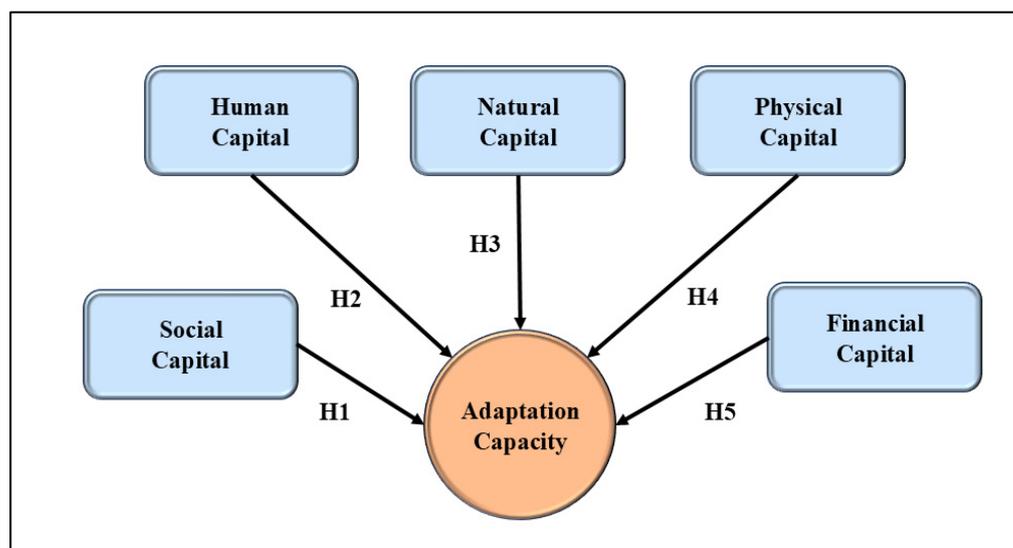


Figure 1. Research hypotheses.

2.2. Social Capital and Collective Action

Social capital—defined as the norms, trust, networks, and social structures that facilitate coordination—serves as a critical resource for collective action and cooperative problem-solving (Coleman, 1988; Putnam, 1993; Woolcock, 1998). In the resilience and sustainable livelihoods literature, social capital has garnered extensive attention for its role in enabling communities to share resources, distribute risks, and respond collectively to disruptions (Amigo, 2024; Liu et al., 2022; Prayitno et al., 2024b).

Theoretically, social capital bridges individual agency and institutional frameworks, easing information flows and reinforcing mutual support (Nunan, 2017; Park et al., 2015). As a critical resource in society, social capital influences how communities can adapt to environmental changes through strengthening collaboration and collective participation (Auliah et al., 2024; Prayitno et al., 2024a). The relationship between social networks and community norms significantly enhances the ability of communities to take collective action that supports sustainable development (Prayitno et al., 2022). Strong social networks encourage inclusive decision-making and resource mobilization, both essential for adaptive strategies. As communities face climate variability, economic downturns, or demographic shifts, robust social ties can enhance the uptake of innovations, improve governance, and facilitate adaptation to change (Rahmawati et al., 2024; Macbeth et al., 2004).

H1. *Social capital has a significant and positive relationship with adaptive capacity, such that communities with stronger social capital can coordinate more effectively and respond more swiftly to shocks.*

2.3. Human Capital as a Catalyst for Adaptation

Human capital—embodied in education, skills, health, and the capacity for innovation—enables communities to assimilate knowledge, embrace new technologies, and engage in productive livelihoods (Schultz, 1961; Jha & Gupta, 2021; Becker, 1993). From a theoretical standpoint, Becker's (1993) theory of human capital and Schultz's (1961) emphasis on the economic value of education highlight how investments in people facilitate problem-solving, improve decision-making, and foster creativity. In rural contexts, human capital provides the intellectual and technical foundation for identifying opportunities, diversifying income sources, and adjusting livelihood strategies under stress (Bitana et al., 2023; Seaborn et al., 2021).

When communities possess diverse skill sets and can rapidly learn from experience, they are better equipped to apply adaptation measures tailored to local conditions. Human capital thus interacts synergistically with other capitals—e.g., skilled individuals can leverage improved infrastructure more effectively or manage natural resources more sustainably—ultimately strengthening the overall adaptive capacity (Li et al., 2017; Kuipers & de Jong, 2023).

H2. *Human capital exerts a significant and positive effect on adaptive capacity, enabling individuals and households to learn, innovate, and adopt new strategies in response to changing conditions.*

2.4. Natural Capital as the Ecological Base

Natural capital—the stock of natural resources including soil, water, biodiversity, and ecosystem functions—forms the ecological base upon which rural livelihoods rest (Ostrom, 1990; Christina, 2018; Costanza et al., 1997). Theoretical frameworks in environmental governance and ecological economics highlight that the sustainable management of natural capital ensures long-term resource availability, enabling flexible responses to environmental stressors (Folke, 2006; Li et al., 2017; Datta & Roy, 2022).

Rural households often rely heavily on natural capital to produce food, fuel, and fibers. By diversifying resource use (e.g., cultivating different crops, integrating agroforestry, adopting soil conservation methods), communities can buffer against climatic variations, pests, and market volatility. When integrated with other capitals—such as infrastructural improvements that enhance irrigation efficiency or social networks that facilitate knowledge sharing—natural capital supports adaptive strategies that maintain ecological integrity and ensure livelihood sustainability (Scoones, 1998; Bebbington, 1999; Ellis, 2000).

H3. *Natural capital contributes significantly and positively to adaptive capacity, as diverse and well-managed resources support flexible livelihood strategies during environmental or economic fluctuations.*

2.5. Physical Capital and the Infrastructure of Adaptation

Physical capital—embodied in infrastructure, equipment, transportation, communication technologies, and energy systems—supports both production and daily life, shaping how communities respond to adverse conditions (Eakin & Luers, 2006; Aqib et al., 2024). In theoretical terms, improved infrastructure reduces transaction costs, enhances mobility, and broadens market access, allowing communities to adjust livelihoods more rapidly. Roads, storage facilities, and information networks make it easier to diversify income streams, adopt new technologies, or evacuate promptly during disasters (Nunan, 2017; Li et al., 2017).

By interacting with other capitals, physical capital strengthens adaptive capacity. For instance, well-constructed roads facilitate the movement of goods and people, amplifying the benefits of human capital (skills and education) and social capital (networks that coordinate resource allocation). Investments in communications technology can spread

knowledge on sustainable farming techniques or early warning alerts, linking natural and human capital toward greater resilience.

H4. *Physical capital has a significant and positive impact on adaptive capacity, allowing communities to reduce transaction costs, enhance mobility, and better exploit opportunities when facing disturbances.*

2.6. Financial Capital: A Conditional Enabler

Financial capital—encompassing income, savings, access to credit, and monetary transfers—serves as a flexible resource that can underwrite investments in other forms of capital (Moser, 1998; Kasim et al., 2017; Dercon, 2002; Barrett et al., 2001). In theory, financial resources can facilitate adaptation by funding training programs, infrastructure projects, or improved resource management initiatives. However, as numerous studies suggest, financial capital alone rarely guarantees resilience (Ibrahim et al., 2017; Robinson & Herbert, 2001).

Without complementary human skills, strong social networks, appropriate infrastructure, and productive natural resources, financial capital may fail to translate into tangible adaptive outcomes. Its effectiveness hinges on how it interacts with and supports other forms of capital, ensuring that resources are allocated efficiently and equitably (Wubayehu, 2020; Scoones, 1998). This conditional nature of financial capital underscores the importance of viewing it as one component within a complex web of capitals rather than as a standalone solution.

H5. *Financial capital is positively associated with adaptive capacity, although its effect may be moderated by or contingent upon the presence of sufficient levels of other forms of capital.*

2.7. Integrative Perspectives and Empirical Approaches

The theoretical contributions regarding human, social, financial, natural, and physical capital are indeed vast, extending across disciplines like development economics, sociology, environmental governance, resilience science, and human geography (Berkes & Ross, 2013; Folke, 2006; Nunan, 2017). The SLA and related frameworks (Chambers & Conway, 1992; DFID, 1999) urge researchers to transcend disciplinary silos, integrating insights that emphasize the interdependence and complementarity of different assets.

Applying integrative methods, such as structural equation modeling, can systematically test how multiple capitals interact to influence adaptive capacity. By doing so, this research addresses previous limitations in the literature, where isolated examinations of single capitals offered incomplete pictures of resilience (Aribi & Sghaier, 2020; Datta & Roy, 2022; Kuipers & de Jong, 2023). A robust theoretical framework not only incorporates a wide range of scholarly perspectives but also encourages empirical approaches that capture complex, non-linear relationships and feedback loops.

2.8. Toward a More Nuanced Understanding of Adaptive Capacity

The enriched theoretical framework presented here is grounded in a comprehensive survey of the literature across multiple fields. By recognizing that each form of capital rests on established theoretical traditions—Becker (1993) and Schultz (1961) for human capital; Coleman (1988) and Putnam (1993) for social capital; Ostrom (1990) and Costanza et al. (1997) for natural capital; infrastructure and technology studies for physical capital; and development economics for financial capital—we better appreciate their individual and collective roles in adaptation.

Such a perspective affirms that adaptive capacity emerges not simply from having certain assets, but from how those assets are combined, managed, and leveraged within a

community's specific social-ecological context (Folke, 2006; Li et al., 2017; Seaborn et al., 2021). This theoretical grounding paves the way for more nuanced empirical investigations and informed policy interventions that promote balanced asset portfolios, foster cooperation, and encourage learning, ultimately guiding rural communities toward greater resilience in the face of uncertainty.

3. Methodology

3.1. Study Area

Karangrejo Village is located in Borobudur District, Magelang Regency, Central Java (Figure 2), covering 174 km² and hosting approximately 2800 residents (Karangrejo Village Profile, 2023). Situated at an altitude of 200–300 m above sea level, its topography ranges from lowlands to hills, fostering fertile agricultural land near the slopes of Mount Merbabu and Mount Merapi. These natural conditions support agriculture as the main economic activity, with rice, secondary crops, and horticultural produce thriving.

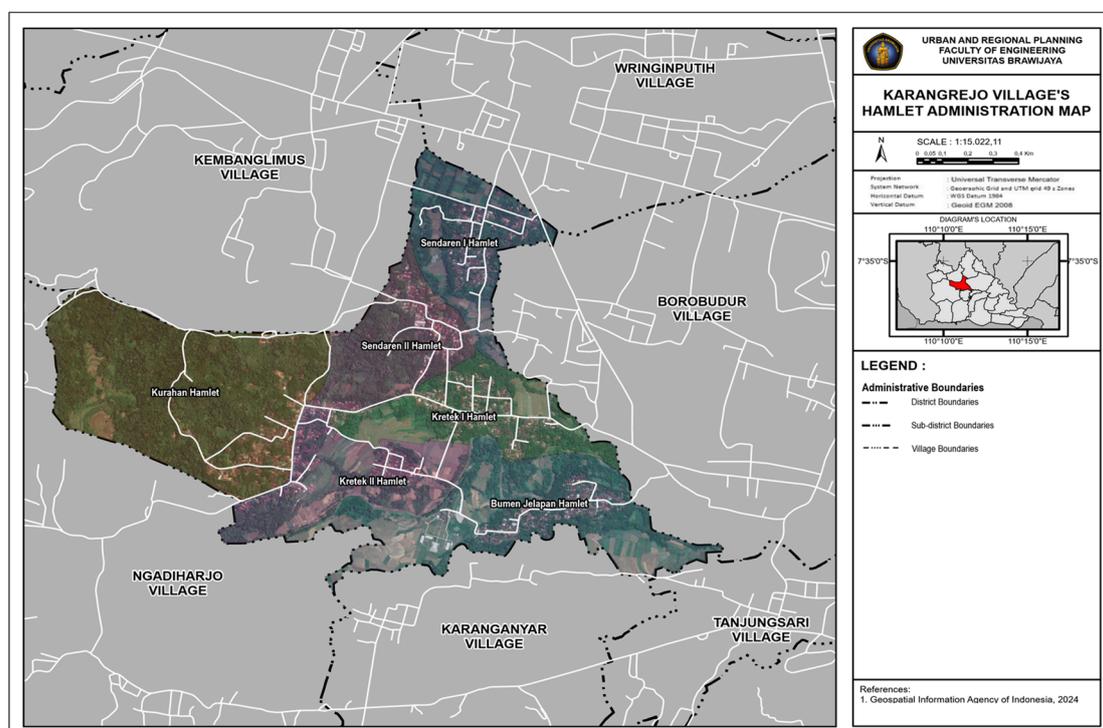


Figure 2. Study area. Source: (Geospatial Information Agency of Indonesia, 2024).

Livelihood assets in Karangrejo Village comprise five main types: natural (e.g., fertile land), physical (e.g., roads connecting the village to the Borobudur Temple tourist area 3 km away), human (e.g., traditional farming skills), social (e.g., strong community cooperation), and financial (e.g., limited but evolving sources of income). While agriculture remains dominant, the proximity to Borobudur Temple presents additional livelihood opportunities in tourism.

Karangrejo Village exemplifies how diverse livelihood assets interact to shape adaptive strategies. Agricultural techniques have evolved to cope with climate variability, including selecting weather-resistant crop varieties. Additionally, economic diversification through tourism and improved disaster preparedness—early warning systems and evacuation procedures for volcanic eruptions—highlight the community's proactive adaptation efforts.

Altogether, these characteristics make Karangrejo Village a relevant case for examining how multiple forms of capital influence adaptive capacity in a rural Indonesian setting.

Its abundant resources, community knowledge, and flexible strategies provide practical insights into fostering resilience against environmental and economic challenges.

3.2. Study Type

This research takes a descriptive quantitative approach. This can be seen from the use of analytical methods and measurements that examine the relationship between predetermined variables.

3.2.1. Sample

The population in this study includes the entire community of Karangrejo Village, totaling 2832 people. To determine the number of representative samples, the Harry King calculation method was used, resulting in 372 respondents. Data collection occurred in-person from June to August 2024, with trained enumerators administering structured questionnaires directly to participants. This face-to-face approach ensured clarity in responses and minimized misunderstandings.

3.2.2. Measurement

The measurement indicators for livelihood assets and adaptive capacity (Table 1) were developed based on the established literature, including the SLA framework, and adapted to the local context of Karangrejo Village. The questionnaire was divided into six sections: (1) adaptive capacity, (2) financial capital, (3) human capital, (4) natural capital, (5) physical capital, and (6) social capital. Each indicator was assessed using a Likert scale (“1” = “very low” to “5” = “very high”).

Table 1. Research variables.

Variable	Indicator	Code
Adaptive Capacity	Community Knowledge about Disaster Adaptation Strategies	AC1
	Use of Adaptation Strategies in Facing Disasters	AC2
	Availability of Adaptation Strategies in the Village	AC3
	Accessibility to Adaptation Strategies	AC4
	Opportunity to Consult with Experts on Adaptation Strategies	AC5
	Personal Experience of Adapting to Disasters	AC6
	Knowledge of Using Technology for Adaptation	AC7
Financial Capital	Savings Ownership	FC1
	Access to Financial and Banking Services	FC2
	Access to Formal and Informal Credit	FC3
	Availability of Social Assistance from the Government	FC4
Human Capital	Access to Education Services	HC1
	Training Received related to Tourism	HC2
	Agricultural and Non-Agricultural Skills	HC3
	Access to Health Services	HC4
	Good Nutritional Status	HC5
Natural Capital	Ownership and Access to Agricultural Land	NC1
	Quality and Productivity of Agricultural Land	NC2
	Availability and Quality of Water for Irrigation	NC3
	Air Quality and Air Pollution Management	NC4
	Availability and Quality of Water for Household Needs	NC5
	Diversity of Plants and Animals Used for Livelihoods	NC6
	Access to Forests, Grasslands, and Other Natural Resources in the Village	NC7
	Adequate Condition of Road Infrastructure	NC8

Table 1. Cont.

Variable	Indicator	Code
Physical Capital	Road Availability	PC1
	Electricity Availability	PC2
	Availability of Public Facilities	PC3
	Availability of Tourism Supporting Infrastructure	PC4
	Ownership and Access to Agricultural Equipment	PC5
	Ownership and Access to Technology	PC6
	Good Housing Conditions	PC7
	Access to Sanitation and Clean Water	PC8
	Access to Transportation and Communication Facilities	PC9
Social Capital	Good Social Network Conditions (Family, Friends, Community).	SC1
	Groups/Organizations that support Economic, Social and Environmental activities (<i>BUMDes (Badan Usaha Milik Desa/Village-Owned Enterprises)</i> , <i>GAPOKTAN (Gabungan Kelompok Tani/Farmer Group Association)</i> , <i>PKK (Pemberdayaan Kesejahteraan Keluarga/Family Welfare Empowerment)</i> , Cooperatives)	SC2
	Benefits of Groups/Organizations in the Economic, Social and Environmental Fields	SC3
	Frequency of Mutual Cooperation or Community Collaboration	SC4
	Involvement in Groups/Organizations (<i>BUMDes</i> , <i>GAPOKTAN</i> , <i>PKK</i> , Cooperatives)	SC5
	Participation in Decision-Making	SC6
	Participation in Regional Government	SC7
	Inter-Community Conflicts Related to Social, Economic, and Environmental Conditions	SC8
	Ease of Resolving Social Conflicts Between Communities	SC9
	Level of Trust Between Community Members	SC10
	Frequency of Conflict Between Communities	SC11
	Level of Understanding of Traditional Culture	SC12
	Satisfaction with Government	SC13
	Compliance with Applicable Group/Government Norms and Regulations	SC14
	Compliance with Applicable Customary Norms and Regulations	SC15
	Compliance with Applicable Religious Regulations	SC16
	Attendance Level in Participating in Social, Economic, and Environmental Activities in the Village	SC17
	The Influence of Community Figures in Decision-Making	SC18
	Level of Youth Involvement in Social Organizations	SC19
	Community Relations with Groups Outside the Village	SC20

3.3. Data Analysis

Data were processed using SmartPLS Version 4, a partial least squares–structural equation modeling (PLS-SEM) software program. SEM-PLS was chosen for its robustness in handling complex models and its suitability for exploratory research where theoretical models are being tested and refined. The analysis begins with evaluating the outer model to ensure the validity and reliability of the indicators, followed by testing the inner model to determine the relationship between the latent variables. This approach allows us to rigorously test hypothesized pathways between livelihood assets and adaptive capacity, thereby providing a statistically and theoretically robust understanding of the factors that shape community resilience.

After the data were collected and processed, the analysis continued using the coefficient of variation to determine the priority of community adaptation strategies to shocks that occurred in Karangrejo Village. SEM-PLS is applied to build and test relationships between latent variables which are divided into outer models and inner models. At the outer model stage, data validity and reliability tests are carried out before proceeding to the inner model to analyze the magnitude of the influence between variables.

4. Results

4.1. Outer Model in SEM-PLS

SEM-PLS analysis was carried out on the livelihood assets and adaptation capacity variables in Karangrejo Village. This analysis was carried out using a measurement model

(outer model) and a structural model (inner model). This analysis begins by building a path diagram. This research looks at the relationship between five capitals in livelihood assets and adaptive capacity. Instrument validity is a crucial aspect that researchers must pay attention to, because validity determines the accuracy of the results of a test. The validity of an instrument or dataset in research measures the extent to which the information contained in the dataset collected or analyzed reflects reality. Therefore, establishing validity is very important. In measuring validity, assessments can be divided into two main types: convergent validity and discriminant validity.

4.1.1. Convergent Validity

Convergent validity refers to the extent to which different variables are correlated in measuring the same construct. This validity ensures that the variables are related to the latent construct being measured, with a strong correlation between the variable and the latent construct. To assess convergent validity, the Average Variance Extracted (AVE) value is used, which indicates the extent to which the items in a construct share variance between them. The expected AVE value is greater than or equal to 0.5 to meet convergent validity. The model is said to be valid when the outer loading (λ) value is >0.7 . This means that it shows that the variable has explained at least 50% of the variance of the indicator. To obtain valid loading factor values, three stages of convergent validity are carried out. If all the indicators are valid, it can be said that the Sustainable Asset indicators (human capital, social capital, natural capital, physical capital, and financial capital) and adaptive capacity can explain the variables well. In the first and second stages, the variables livelihood assets and adaptation capacity still have invalid values, so invalid indicators need to be discarded (Table 2).

Table 2. Outer loading value.

Variable	Indicators	Phase 1		Phase 2		Phase 3	
		λ	Note	λ	Note	λ	Note
Adaptation Capacity	AC1	0.272	Invalid	-	-	-	-
	AC2	0.608	Invalid	-	-	-	-
	AC3	0.397	Invalid	-	-	-	-
	AC4	0.735	Valid	0.870	Valid	0.870	Valid
	AC5	0.719	Valid	0.809	Valid	0.809	Valid
	AC6	0.143	Invalid	-	-	-	-
	AC7	0.616	Invalid	-	-	-	-
Financial Capital	FC1	0.863	Valid	0.849	Valid	0.849	Valid
	FC2	0.880	Valid	0.872	Valid	0.872	Valid
	FC3	0.886	Valid	0.885	Valid	0.885	Valid
	FC4	0.853	Valid	0.868	Valid	0.868	Valid
Human Capital	HC1	-0.056	Invalid	-	-	-	-
	HC2	0.716	Valid	0.770	Valid	0.771	Valid
	HC3	0.702	Valid	0.837	Valid	0.837	Valid
	HC4	0.679	Invalid	-	-	-	-
	HC5	-0.009	Invalid	-	-	-	-
Natural Capital	NC1	0.652	Invalid	-	-	-	-
	NC2	0.907	Valid	0.914	Valid	0.914	Valid
	NC3	0.584	Invalid	-	-	-	-
	NC4	0.788	Valid	0.809	Valid	0.809	Valid
	NC5	0.708	Valid	0.729	Valid	0.729	Valid
	NC6	0.802	Valid	0.839	Valid	0.839	Valid
	NC7	0.481	Invalid	-	-	-	-
	NC8	0.845	Valid	0.883	Valid	0.883	Valid

Table 2. Cont.

Variable	Indicators	Phase 1		Phase 2		Phase 3	
		λ	Note	λ	Note	λ	Note
Physical Capital	PC1	0.911	Valid	0.919	Valid	0.919	Valid
	PC2	0.903	Valid	0.906	Valid	0.906	Valid
	PC3	0.907	Valid	0.925	Valid	0.925	Valid
	PC4	0.810	Valid	0.802	Valid	0.802	Valid
	PC5	−0.108	Invalid	-	-	-	-
	PC6	0.893	Valid	0.886	Valid	0.886	Valid
	PC7	−0.097	Invalid	-	-	-	-
	PC8	−0.146	Invalid	-	-	-	-
	PC9	−0.083	Invalid	-	-	-	-
Social Capital	SC1	−0.068	Invalid	-	-	-	-
	SC10	−0.304	Invalid	-	-	-	-
	SC11	0.762	Valid	0.798	Valid	0.819	Valid
	SC12	0.704	Valid	0.713	Valid	0.719	Valid
	SC13	0.771	Valid	0.720	Valid	0.715	Valid
	SC14	0.706	Valid	0.696	Invalid	-	-
	SC15	−0.193	Invalid	-	-	-	-
	SC16	0.871	Valid	0.865	Valid	0.850	Valid
	SC17	0.696	Invalid	-	-	-	-
	SC18	−0.217	Invalid	-	-	-	-
	SC19	0.729	Valid	0.758	Valid	0.762	Valid
	SC2	−0.245	Invalid	-	-	-	-
	SC20	0.785	Valid	0.824	Valid	0.826	Valid
	SC3	0.755	Valid	0.801	Valid	0.810	Valid
	SC4	−0.172	Invalid	-	-	-	-
	SC5	−0.327	Invalid	-	-	-	-
	SC6	−0.115	Invalid	-	-	-	-
	SC7	0.799	Valid	0.799	Valid	0.809	Valid
	SC8	−0.386	Invalid	-	-	-	-
	SC9	−0.026	Invalid	-	-	-	-

Note: Cells highlighted in orange indicate variables or indicators deemed invalid during the analysis stages, while unhighlighted cells represent valid indicators.

Based on Table 2 and Figure 3, it can be seen that in the first stage of analysis, variables with invalid indicators were deleted, so that only variables with valid indicators remained. After this stage, only a small number of variables met the validity criteria. In the second stage, a recalculation is carried out by only considering valid variables. The results show an increase in the number of variables that meet validity standards. After the third stage, by carrying out further evaluation and removing invalid indicators, all remaining variables show valid results. This indicates that the model used meets the overall validity criteria. Thus, this analysis ensures that all variables involved in the research have valid indicators and can be used to describe the adaptive capacity being analyzed. Cells highlighted in orange indicate variables or indicators (Table 2) deemed invalid during the analysis stages, while unhighlighted cells represent valid indicators. The colors are used to differentiate valid and invalid indicators across the phases of analysis.

Next, a construct validity test was carried out by looking at the AVE, Cronbach alpha and composite reliability values. The AVE value is said to meet the criteria by having a limit value of more than or equal to 0.5. Based on variable calculations, it can be seen that each variable has AVE, Cronbach alpha and composite reliability values that meet the requirements or are valid. Therefore, it can be interpreted that the SEM-PLS model can describe the livelihood assets and adaptation capacity variables well. The following are the results of the calculations (Table 3).

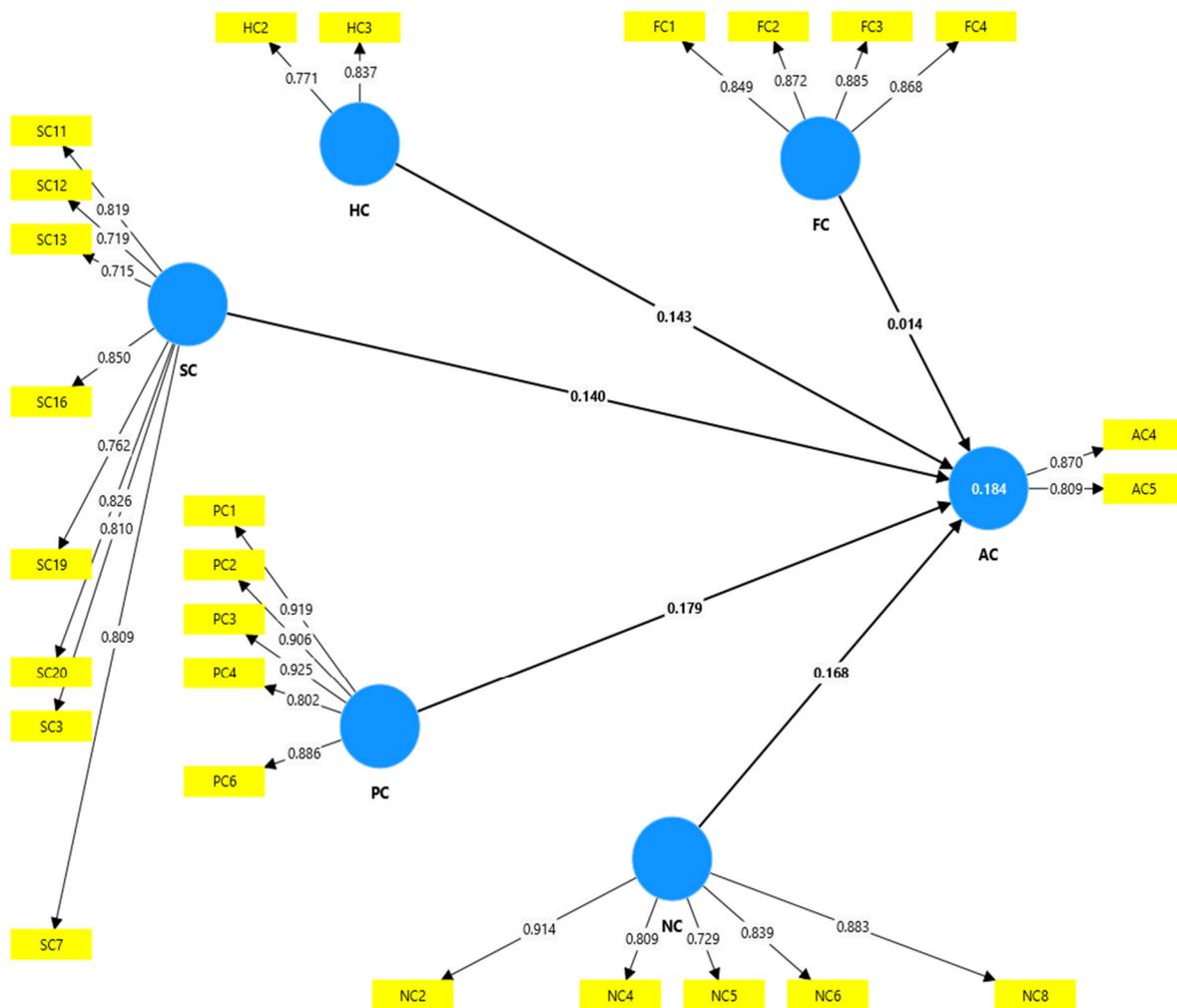


Figure 3. Outer model.

Table 3. Cronbach alpha (α), composite reliability (CR), and AVE values.

Variable	α	CR	AVE
Adaptation Capacity	0.586	0.597	0.706
Financial Capital	0.895	0.938	0.755
Human Capital	0.457	0.464	0.647
Natural Capital	0.892	0.899	0.701
Physical Capital	0.933	0.946	0.789
Social Capital	0.915	0.928	0.624

Thus, the model and all the SEM-PLS livelihood assets variables have demonstrated good convergent validity. Next, the inner model stage can be carried out. The composite reliability value shows that all the constructs in the proposed measurement model exceed 50%, and the corresponding Cronbach’s alpha coefficient is greater than 50%. Thus, all latent variables in the proposed model show good reliability. Validity shows that the average AVE for all constructs exceeds 60%. This indicates that the constructs in the proposed model have adequate convergent validity. So, these findings indicate that the indicators for all the constructs have a high percentage of variance attributed to other constructs.

4.1.2. Discriminant Validity

Discriminant validity is established to ensure that each construct in the research has clear distinctiveness and identity. This means that these constructs do not have excessive

correlation with other constructs in the research. In SEM-PLS, discriminant validity is assessed using the Fornell and Larcker Criteria. Discriminant validity is considered fulfilled if the square root of the AVE for a construct is greater than its correlation with all other constructs (Table 4).

Table 4. Fornell–Larcker criteria.

Constructs	1	2	3	4	5	6
1 AC	0.840 *					
2 FC	0.250 **	0.869 *				
3 HC	0.272 **	0.410 **	0.805 *			
4 NC	0.285 **	0.723 **	0.380 **	0.837 *		
5 PC	0.305 **	0.197 **	0.206 **	0.159	0.888 *	
6 SC	0.276 **	0.143 **	0.156 **	0.150 **	0.475 **	0.777 *

* Square root of AVE estimate; ** Correlation is significant at the <0.01 level.

Based on the square root value of AVE in Table 4, it can be seen that for all constructs, the square root of AVE is greater than their correlation with all the other constructs. In general, the root value of AVE for all constructs ($0.777 < AVE < 0.888$) is higher than the correlation between these constructs ($0.143 < r < 0.723$). These findings indicate that the indicators for all the constructs account for a high percentage of the variance attributed to other constructs.

4.2. Inner Model in SEM-PLS

In SEM-PLS analysis, the inner model is evaluated using the R-square value and significance. The R-square value is used to determine whether the model is classified as strong, medium, or weak. Additionally, significance tests help identify whether the model is significant or not. The following are the results of the R-square test and significance for the SEM-PLS model.

Based on the results (Table 5 and Figure 4), the R-square value is 0.184. Therefore, adaptive capacity is said to be a weak model which indicates the model has quite low predictive power. Next, the significance value calculation is carried out to determine the significance value of each path coefficient in the SEM-PLS model. Variables have a significant relationship only if they have a t-statistic > t table. So, the p value is >0.05. Based on the significance value, it is known that each path coefficient has a significant and positive value. The significance value of the SEM-PLS model is shown in the table above showing each significance value of the research variables.

- (a) Financial capital does not have a significant influence on adaptive capacity. The relationship created by financial capital has a t-statistic value of 0.232, so it is <1.96 (t-table). Then, the total p value is >0.05, with a value of 0.817. Therefore, the result indicates that the value exceeds the threshold and does not meet the criteria for significance. So, financial capital does not have a significant influence on adaptive capacity, with an original sample value of 0.014.
- (b) Human capital has a significant influence on adaptive capacity. The relationship created by human capital has a t-statistical value of 2947, so it is >1.96 (t-table). Then, the total p value is < 0.05, with a value of 0.003. Therefore, the result confirms that the value satisfies the criteria for significance. So, human capital has a significant influence on adaptive capacity, with an original sample value of 0.143.
- (c) Natural capital has a significant influence on adaptive capacity. The relationship created by natural capital has a t-statistic value of 2667, so it is >1.96 (t-table). Then, the total p value is < 0.05, with a value of 0.008. Therefore, the result confirms that

- the value satisfies the criteria for significance. So, natural capital has a significant influence on adaptive capacity, with an original sample value of 0.168.
- (d) Physical capital has a significant influence on adaptive capacity. The relationship created by physical capital has a t-statistical value of 3.115, so it is >1.96 (t-table). Then, the total *p* value is < 0.05, with a value of 0.002. Therefore, the result confirms that the value satisfies the criteria for significance. So, physical capital has a significant influence on adaptive capacity, with an original sample value of 0.179.
 - (e) Social capital has a significant influence on adaptive capacity. The relationship created by social capital has a t-statistical value of 2461, so it is >1.96 (t-table). Then, the total *p* value < 0.05, with a value of 0.014. Therefore, the result confirms that the value satisfies the criteria for significance. So, social capital has a significant influence on adaptive capacity, with an original sample value of 0.140.

Table 5. Significance value.

Path Coefficient	Original Sample	T-Statistics	<i>p</i> Values	Hypotheses	R2
FC → AC	0.014	0.232	0.817	Rejected	
HC → AC	0.143	2.947	0.003	Confirmed	
NC → AC	0.168	2.667	0.008	Confirmed	0.184
PC → AC	0.179	3.115	0.002	Confirmed	
SC → AC	0.140	2.461	0.014	Confirmed	

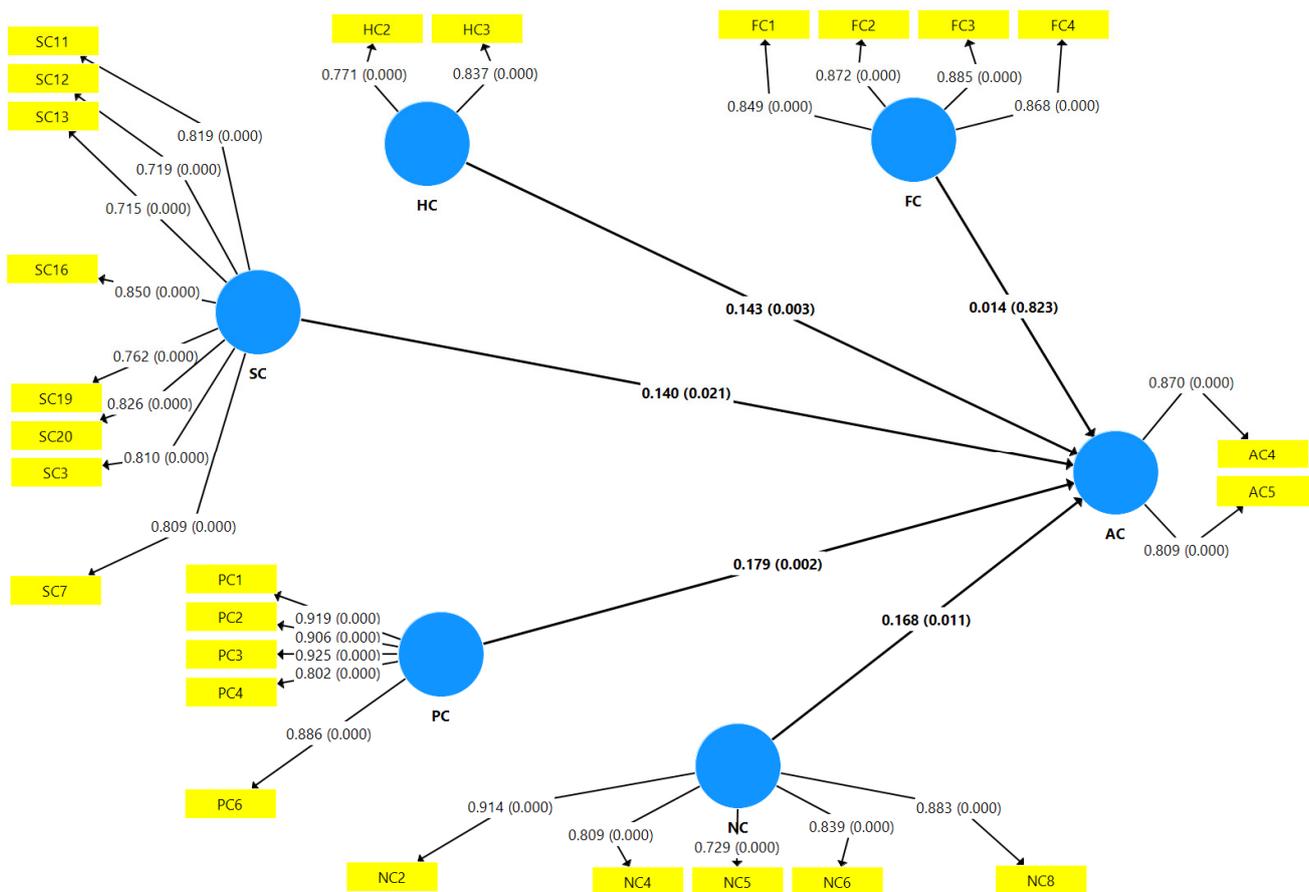


Figure 4. Inner model.

Thus, it can be concluded that livelihood assets consisting of natural capital, physical capital, human capital, and social capital can encourage community adaptation capacity in

facing shocks. Livelihood assets become a community's strength in overcoming emergency conditions to achieve community resilience in adapting.

5. Discussion

5.1. Integrating Multiple Livelihood Assets

The findings of this study underscore the interdependence of human, natural, physical, social, and financial capital in shaping rural communities' adaptive capacity to shocks. While the existing literature often treats these capitals in isolation, the results here highlight their synergy, showing that combining certain forms of capital fosters more robust resilience strategies (Scoones, 1998; Bebbington, 1999; Ellis, 2000; Nunan, 2017). This integrated perspective aligns with broader social-ecological resilience frameworks, which argue that adaptation emerges from diverse interactions among economic, social, cultural, and environmental assets (Folke, 2006; Li et al., 2017; Vallury et al., 2022).

By applying a holistic analytical approach—drawing on the SLA and employing SEM—this study moves beyond a piecemeal understanding of adaptation. Instead, it illuminates how multiple capitals, viewed collectively, enable communities to navigate uncertainty, diversify livelihood strategies, and maintain critical functions under changing conditions. This insight confirms the value of comprehensive frameworks rather than narrowly focusing on financial or physical aspects (Aribi & Sghaier, 2020; Liu et al., 2022; Aqib et al., 2024).

5.2. The Role of Human Capital in Adaptive Capacity

Human capital—encompassing knowledge, skills, education, and health—emerges as a pivotal factor in enhancing adaptive capacity. The findings agree with prior research indicating that technical training and diversified skills help communities respond more effectively to new economic opportunities and environmental challenges (Bitana et al., 2023; Jha & Gupta, 2021). A skilled population can assimilate novel technologies, engage in flexible livelihood options, and better navigate both expected and unforeseen shocks.

Moreover, human capital supports learning and innovation, aligning with views that adaptive capacity partly depends on a society's ability to generate, process, and apply information to decision-making (Li et al., 2017; Seaborn et al., 2021). This dynamic supports other forms of capital—for instance, using infrastructure more effectively or managing natural resources in a more sustainable way—ultimately contributing to a coherent and informed adaptive strategy.

5.3. Natural and Physical Capital Synergies

Natural capital—including land, water, and biodiversity—forms the ecological foundation of rural livelihoods (Datta & Roy, 2022; Christina, 2018; Sadiq et al., 2024). Access to and maintenance of these resources allows communities to adjust agricultural practices, diversify crops, and explore ecosystem-based management strategies. The findings confirm that natural capital's value is magnified when complemented by physical capital such as infrastructure, irrigation, roads, and communication (Eakin & Luers, 2006; Aqib et al., 2024).

Physical capital, including transport networks and communication technologies, underpins the effective utilization of natural capital. Better roads facilitate market access, while reliable irrigation systems enhance agricultural productivity. Investing in both can therefore strengthen rural communities' responses to environmental stressors and market fluctuations more effectively.

5.4. The Importance of Social Capital for Collective Action

Social capital—trust, networks, and norms—binds communities together, facilitating collective responses to shocks. Higher levels of social capital enable efficient coordination, resource sharing, and problem-solving (Prayitno et al., 2024b; Rahmawati et al., 2024; Amigo, 2024). These social ties become invaluable during crises, allowing pooling of resources, exchange of vital information, and sustained cooperation in the face of adversity.

This study's findings support the notion that social capital enhances adaptive capacity by creating an environment where collective-level adaptation strategies can flourish (Liu et al., 2022; Nunan, 2017). As communities confront climate change or socio-economic transitions, robust social networks can expedite recovery and encourage innovation. Social capital thereby reinforces trust, fosters inclusive decision-making, and ensures that infrastructural, financial, or technological interventions reach community members effectively.

5.5. Revisiting Financial Capital: Complexity and Limitations

Financial capital—savings, income, and credit—remains a vital resource for rural livelihoods, yet these findings show that financial assets alone may not assure enhanced adaptive capacity (Moser, 1998; Kasim et al., 2017). This aligns with earlier studies indicating that financial resources must be complemented by other forms of capital to translate into genuine resilience. For instance, households with savings may still struggle if they lack knowledge of suitable adaptation strategies, have weak social networks, or manage degraded natural resources.

Rather than minimizing financial capital's importance, the results place it in context: financial capital can fund investments in education, infrastructure, or resource management but is less effective if other capitals are absent or underdeveloped. Consequently, an integrated approach is recommended, leveraging financial resources to build human, social, natural, and physical capital simultaneously.

6. Conclusions

This study has demonstrated that enhancing adaptive capacity in rural communities requires coordinated investment in human, natural, physical, social, and financial capital. Findings in Karangrejo Village reveal that these diverse forms of capital, when leveraged collectively, substantially strengthen the community's ability to withstand varied shocks. In contrast, focusing solely on financial capital has limited impact, highlighting the need for balanced attention to both tangible and intangible assets, such as education, social cohesion, and environmental conservation.

From a policy perspective, holistic interventions that reinforce multiple capitals simultaneously are more likely to foster long-term resilience. For instance, investing in vocational training (human capital) and community networks (social capital) can amplify the benefits of infrastructure upgrades (physical capital). Similarly, financial assistance programs are most effective when paired with strategies that protect natural resources and strengthen social cooperation.

A key limitation of this research is its narrow geographical scope, focusing on a single village in Central Java. While this context provides rich insights into how integrated livelihood assets shape adaptive capacity, caution is advised in generalizing the findings to other regions with different socio-ecological conditions. Future studies could adopt longitudinal or mixed-method designs to capture evolving dynamics and incorporate cultural factors not easily quantified. By exploring the interplay of capitals over time and across diverse contexts, researchers and practitioners can better identify tailored strategies to strengthen rural resilience globally.

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