Impact of Livelihood Capital on Sensitivity of Livelihood Strategy Choices among Rural Households in Sand-Sealed Areas: A Case Study of Linze County (Postprint)

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Abstract

Desertified Land Closure Protection Area (DLCPA) represents an important approach in China for preventing land desertification, restoring regional vegetation, maintaining ecological security, and promoting sustainable economic and social development through enclosure and other methods on contiguous desertified land that is temporarily unsuitable for treatment and development. As the principal actors in DLCPAs, farming households are impacted by the establishment of these areas. To investigate how livelihood capital influences livelihood strategy choices in this region, this study employs Participatory Rural Appraisal (PRA), taking Linze County, Zhangye City, a DLCPA, as a case study. Based on the Sustainable Livelihoods Approach (SLA) analytical framework and combined with a binary Logistic regression model, it analyzes the sensitivity effects of farming households' livelihood capital on livelihood strategy selection. The results indicate that: (1) Natural and human capital significantly influence the choice of purely agricultural livelihood strategies, physical and social capital exert significant effects on the choice of pluriactive livelihood strategies, while financial capital represents the most critical factor influencing the choice of non-agricultural livelihood strategies. (2) The stock of farming households' livelihood capital influences their selection among different types of livelihood strategies; the greater the stock, the stronger the sensitivity of choice. (3) Significant differences exist among different household types regarding their willingness to adjust existing livelihood strategies: 68% of purely agricultural households and 56% of pluriactive households express a desire to adjust their current livelihood strategies, whereas 63% of non-agricultural households show no intention of adjusting their existing strategies. These findings provide an important theoretical basis for enhancing farming households' livelihoods and

ecological security in DLCPAs and promoting sustainable socioeconomic development.

Full Text

The Impact of Livelihood Capital on the Sensitivity of Livelihood Strategy Selection Among Farmers in Sand-Sealed Areas: A Case Study of Linze County

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Abstract

Sand-sealed protection areas (sand-sealed areas) represent a critical measure in China for preventing land desertification, restoring regional vegetation, maintaining ecological security, and promoting sustainable economic and social development in contiguous sandy lands that are not yet suitable for control measures or development. As the primary actors in sand-sealed areas, farmers are directly affected by the establishment of these protection zones. This study investigates how livelihood capital influences livelihood strategy selection in such regions using the Participatory Rural Appraisal (PRA) method, taking Linze County in Zhangye City as a case study. Building upon the Sustainable Livelihoods Approach (SLA) framework and employing a binary Logistic regression model, we analyze the sensitivity of farmers' livelihood capital to their livelihood strategies. The results demonstrate that: (1) Natural and human capital significantly influence the choice of pure agricultural livelihood strategies, while material and social capital significantly affect the selection of diversified agricultural strategies, and financial capital represents the most important factor for non-agricultural strategy selection. (2) The stock of livelihood capital affects farmers' choice among different strategy types, with greater stocks leading to stronger selection sensitivity. (3) Different farmer types exhibit substantial variation in their willingness to adjust existing strategies: 68% of pure farmers and 56% of diversified farmers hope to adjust their current strategies, whereas 63% of non-farmers show no such willingness. These findings provide an important theoretical basis for improving livelihood and ecological security among farmers in sand-sealed areas and for promoting sustainable socioeconomic development.

Keywords: desertification protection area; livelihood capital; livelihood strategy; sensitivity; Logistic model

1. Introduction

Land desertification refers to the process in arid and semi-arid regions where natural factors and human activities transform non-desert areas into desert-like environments, causing vegetation degradation and ecosystem damage. Northwest China suffers the most severe land desertification in the country, with Gansu Province's sandy land covering 1217.02$\times10^{4}$ hm^2, representing 28.6% of the province's total area. Sealed protection constitutes a crucial anti-desertification measure. Since 2013, China has implemented pilot projects for sand-sealed protection areas, progressively expanding this work. These protection zones primarily employ mandatory measures including grazing bans, fencing, and patrols to eliminate human disturbance, alleviate land pressure, and create conditions for natural ecological restoration, thereby protecting and recovering vegetation. This approach plays a vital role in curbing desertification expansion and promoting coordinated ecological, economic, and social development in sandy regions.

A livelihood represents the means of subsistence based on assets, capabilities, and activities. A livelihood becomes sustainable when it can cope with and recover from stresses and shocks while maintaining or enhancing its capabilities and assets both currently and in the future without undermining the natural resource base. To study sustainable livelihoods, scholars have proposed various analytical frameworks, among which the Sustainable Livelihoods Approach (SLA) developed by the UK Department for International Development (DFID) has gained the widest application. This framework comprises five components: natural capital, physical capital, financial capital, social capital, and human capital, revealing how households utilize available capital and potential strategies to pursue livelihoods. The impact of livelihood capital on livelihood strategies occurs through changes in capital stock and reconfiguration patterns, with different capital endowments exhibiting varying sensitivity characteristics.

Previous research has primarily focused on farmer livelihood vulnerability, risk assessment, and quantitative analysis of livelihood capital, particularly among pastoralists and ethnic minorities in river valley and plateau mountain regions. Cui et al. found that social and natural capital influence pure and semi-pastoral households' strategy choices in agro-pastoral transition zones. Ubiali identified physical and social assets as primary determinants for different livelihood strategies. Other scholars noted China's lack of research examining the relationship between livelihood capital and strategies from different village and household type perspectives. Yang et al. determined that physical and natural capital are key factors for pure farmers transitioning to non-farmers, with capital deficits driving shifts to alternative strategies. However, comprehensive studies remain scarce on how livelihood capital endowments affect strategy selection in sand-sealed areas and the sensitivity of different farmer types to these choices.

Linze County, located in the middle Hexi Corridor of Gansu Province along the southern edge of the Badain Jaran Desert, faces severe water shortages and

desertification, with sandy land comprising 51.5% of its total area. In 2014, the county established the Linze County Northern Arid Desert National Sand-Sealed Protection Area, which constitutes a critical wind-sand source threatening the northern oasis ecological security. Given the county's unique topographical conditions and extensive desertified land, examining the relationship between livelihood capital and strategy selection provides dual significance for achieving farmers' livelihood goals and strategy adjustment, while offering theoretical support for improving livelihood and ecological security.

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2. Study Area and Methods

2.1 Study Area Overview

Linze County is situated in central Gansu's Hexi Corridor (99°51'–100°30'E, 38°57'–39°42'N), bordering Zhangye's Ganzhou District to the east, Gaotai County to the west, the Qilian Mountains to the south, and the Inner Mongolia Autonomous Region's Alxa Right Banner to the north. The county covers 2727$×10^{4}$ hm^2 with elevations ranging from 1380–2278 m. Characterized by a temperate continental arid desert climate, the region experiences long sunshine hours, strong solar radiation, minimal and concentrated precipitation, high evaporation, and dry conditions. Based on multi-year meteorological data from Linze Station, average annual precipitation is 117.2 mm while evaporation reaches 2337.6 mm.

Irrigation-based agriculture dominates, with crop area covering 322.66$×10^{4}$ hm^2 (51.5% of total area). Major crops include corn, soybeans, medicinal herbs, and wheat. The county boasts abundant grassland resources and developed animal husbandry, with artificial grassland area of 1.14$×10^{4}$ hm^2 and grassland coverage of 24.1%. Forestry resources are also substantial, with artificial afforestation of 3066.67 hm^2 and forest coverage of 16.66%. The county comprises three townships and four administrative villages with a total population of 12.7$×10^{4, including 14.5×10^{4}}$ agricultural residents in 4$×10^{4}$ households (representing 51.5% of total population). The northern sandy area covers 10.7$×10^{4}$ hm^2. Through combined biological and engineering sand control measures, the county has implemented sand suppression projects covering 4080 hm^2, planted Haloxylon ammodendron on 9533 hm^2, and established 1.8$×10^{4}$ hm^2 of windbreak forests. Water resources primarily depend on the Heihe River and groundwater, with scarcity representing a major development constraint.

2.2 Data Sources and Methods

Data were collected through Participatory Rural Appraisal (PRA) household surveys conducted in mid-July 2021. Using stratified sampling, we surveyed Pingchuan Town and Nijiaying Town, covering Wulidun Village, Leitai Village,

Wangjiadun Village, and Nijiaying Village. Of 130 distributed questionnaires, 129 were valid (99.23% validity rate). Drawing on Su Fang's livelihood strategy classification, we categorized farmers into pure agricultural, diversified agricultural, and non-agricultural types based on local conditions, facilitating more convenient analysis. The sample included 46 pure farmers, 44 diversified farmers, and 39 non-farmers. Questionnaires covered 20 indicators across five livelihood capital dimensions plus household characteristics in sand-sealed areas, using repeated questioning to ensure authenticity.

2.2.1 Livelihood Capital Measurement Indicators Based on the SLA framework and existing research, we developed 20 indicators across five dimensions tailored to Linze County's ecological environment and resource endowments:

- **Natural Capital (N):** Per capita cultivated land area (N_1) and grassland area (N_2), given the county's developed agriculture and animal husbandry.
- **Human Capital (H):** Education level (H_1), health status (H_2), skills training (H_3), and household labor force (H_4), representing education, health, skills, and labor capacity.
- **Physical Capital (P):** Home appliances (P_1), production tools (P_2), livestock numbers (P_3), and housing quality (P_4), representing public infrastructure and production means.
- **Financial Capital (F):** Savings amount (F_1), loan amount (F_2), and total household income (F_3), representing financial resources for livelihood objectives.
- **Social Capital (S):** Number of people providing help (S_1), household gift expenditure (S_2), and social connections (S_3), reflecting ability to access and utilize social resources.

2.2.2 Livelihood Capital Calculation We employed the entropy method to calculate livelihood capital weights and values:

1. **Entropy value calculation** for indicator j:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} P_{ij} \ln P_{ij}$$

2. **Weight calculation** for indicator j:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)}$$

3. **Livelihood capital value** for indicator j:

$$F_j = \sum_{j=1}^{n} W_{jP_{ij}}$$

4. **Sensitivity index calculation** for indicator j:

$$S_j = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} W_{jP_{ij}}}{\sum_{i=1}^{m}\sum_{j=1}^{n} W_{jP_{ij}}}$$

2.2.3 Binary Logistic Regression Model We constructed a binary Logistic model to measure livelihood capital sensitivity to strategy selection. With livelihood strategy as the dependent variable (constant, taking values 0 or 1) and P representing the probability of non-agricultural strategy selection, the model is:

$$P = \frac{\exp(\partial + \beta_{1x}1 + \beta_{2x}2 + \cdots + \beta_{ix}i)}{1 + \exp(\partial + \beta_{1x}1 + \beta_{2x}2 + \cdots + \beta_{ix}i)}$$

Where is the intercept and β represents estimated parameters (if $\beta > 0$, the probability increases with the variable when others remain constant; if $\beta < 0$, the opposite occurs). The contribution rate of livelihood capital to strategy selection is represented by B.

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3. Results

3.1 Livelihood Capital Analysis by Farmer Type

Pure farmers' livelihood capital values ranked as: natural capital (0.214) > human capital (0.198) > physical capital (0.192) > financial capital (0.186) > social capital (0.168). Natural and human capital carried higher weights compared to other capitals. Diversified farmers showed natural capital (0.203) as highest, followed by substantial human capital (0.201) and physical capital (0.199), with higher weights in human and physical capital. Non-farmers' capital values ranked as: social capital (0.211) > financial capital (0.208) > human capital (0.201) > physical capital (0.194) > natural capital (0.186), with physical and financial capital weights being notably higher.

3.2 Sensitivity Analysis of Livelihood Capital to Strategies

Using the sensitivity index formula and treating strategies as quantitative data (values 0–1), we conducted single-factor sensitivity analysis. Results show (Figure 2):

- **Pure farmers:** Sensitive sub-capital indicators include N_1 (0.061) in natural capital, H_1 (0.058) and H_4 (0.052) in human capital, and F_3 (0.049) in financial capital.
- **Diversified farmers:** Sensitivity concentrates on H_4 (0.064) in human capital, F_3 (0.058) in financial capital, and S_3 (0.055) in social capital.

- **Non-farmers:** The most sensitive indicators are H_4 (0.079) in human capital, F_3 (0.082) in financial capital, and S_3 (0.082) in social capital.

3.3 Impact of Livelihood Capital on Strategy Sensitivity

Using the Logistic regression model with five livelihood capitals as independent variables and three strategy types as dependent variables (Table 4), we analyzed capital impacts on strategies. The Chi-square values for pure, diversified, and non-farmers were 15.068, 5.639, and 6.302 respectively, with degrees of freedom (df) = 5 and significance levels of 0.010, 0.344, and 0.276. Homsmer-Lemeshow test values were 0.588, 0.869, and 0.688, indicating good model fit and reflecting livelihood capital's influence on strategy selection.

For pure farmers, natural (B = 2.805), human (B = 3.412), and physical (B = 4.315) capitals showed significant positive effects. With other variables constant, each one-unit increase in these capitals increased the probability of choosing pure agricultural strategies by 2.805, 3.412, and 4.315 times respectively. Compared to pure farmers, diversified farmers possess more human and physical capital plus increased social (B = 3.215) and financial (B = 2.614) capital, making them 3.215 times more likely to choose diversified strategies. For non-farmers, financial (B = 5.214) and physical (B = 3.612) capitals were the primary influencing factors, with each one-unit increase raising the probability of non-agricultural strategy selection by 5.214 times.

3.4 Adjustment of Sustainable Livelihood Strategies by Farmer Type

Detlef argues that the sustainability of farmers' livelihood development depends on their chosen strategies, with reasonable strategies helping achieve resource optimization. Different farmer types show varying willingness to adjust strategies (Table 5). Among pure farmers, 68% hope to adjust strategies, primarily toward off-farm work and part-time farming, while 32% resist change due to low education levels and lack of technical skills. For diversified farmers, 56% are willing to adjust toward specialized agricultural operations and scaled animal husbandry, while 44% hesitate due to insufficient natural capital, lack of breeding experience, technical barriers, and marketing difficulties. Among non-farmers, 37% wish to adjust toward commerce and local factory establishment, but 63% are unwilling due to capital shortages, high risks, and poor transportation infrastructure, fearing investment losses.

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4. Discussion

The quantity of livelihood capital possessed by different farmer types critically influences their selection among pure agricultural, diversified agricultural, and non-agricultural strategies. Our findings align with Wei et al., showing that abundant natural and human capital predisposes farmers toward pure agricul-

ture, while material and social capital favor diversified strategies, and financial capital primarily drives non-agricultural choices. Linze County's unique topography concentrates agricultural and pasture land, with agricultural populations comprising 51.5% of residents, providing ample labor. Human and physical capital accumulation—through household labor, skills training, production tools, and livestock—combined with higher education facilitates modern agricultural techniques, mechanization, and scaled production, enabling agricultural transformation and upgrading. Greater financial capital stock increases the probability of non-agricultural strategy selection, as farmers can engage in off-farm work, commercial services, or develop animal husbandry using local grassland resources under government support, establishing meat production or processing facilities. Additionally, the county's abundant economic crops (grape, high-pepper, corn seeds) offer significant income potential when produced at scale, enhancing financial capital and livelihood capacity.

Livelihood capital stock directly affects strategy selection sensitivity, with greater stocks yielding stronger sensitivity—consistent with findings by Quan and Dao. Larger cultivated areas and adequate labor facilitate intensive, scaled agricultural production, improving efficiency and income. Increased income enables farmers to acquire technology and equipment for secondary and tertiary industries. Non-agricultural strategy sensitivity primarily manifests in financial and social capital, as higher incomes promote diversification, broaden information and funding channels, reduce employment costs, and help accumulate capital for rational strategy formulation.

Different farmer types exhibit substantial variation in adjustment willingness, consistent with Wu's conclusion that strategy adjustment depends on capital endowments. Pure farmers depend heavily on natural capital, using abundant land for efficient agricultural production. Diversified farmers rely on human and physical capital for multiple activities including off-farm work, contracted land operations, and concentrated breeding, achieving greater production efficiency. Non-farmers depend on financial and social capital for commercial services and factory investment under sufficient funding, processing agricultural products to boost local economies and provide off-season employment. However, lacking capital, technology, and policy support creates excessive production risks and potential losses, fundamentally deterring strategy adjustment.

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5. Conclusion

Using Linze County's sand-sealed area as a case study, we investigated local farmers' actual conditions across two towns and four villages, examining different farmer types' livelihood capitals and three corresponding strategy types. By analyzing cultivation, breeding, labor, housing, and income data to quantify livelihood capital, combined with SLA framework and binary Logistic analysis, we conclude:

1. **Diversified livelihood capital significantly impacts strategy selection.** Abundant natural and human capital leads to pure agricultural strategies; material and social capital favor diversified strategies; financial capital primarily influences non-agricultural strategies. Appropriate strategy selection helps farmers optimize resources, protect ecology, and enhance livelihood capacity.
2. **Livelihood capital stock affects selection sensitivity, with greater stocks increasing sensitivity.** This helps farmers choose appropriate strategies and improve livelihood capabilities.
3. **Different farmer types show substantial variation in adjustment willingness.** Pure and diversified farmers demonstrate stronger adjustment intentions, while non-farmers are more reluctant due to capital shortages, high risks, and poor infrastructure.

These findings provide crucial theoretical guidance for improving farmers' livelihood and ecological security in sand-sealed areas while promoting sustainable socioeconomic development.

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Note: Figure translations are in progress. See original paper for figures.