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TRACK 04
GOVERNANCE

Pursuing total volume or efficiency? A study on the coupling pattern of rural population and space: A case study from Huangyan District, Zhejiang Province, China

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1.Literature Review and Theoretical Framework

1.1 Aggregate Coupling Model

Existing research on the coupling between residential population and built-up spaces predominantly focuses on absolute coupling, which posits that within a defined geographical unit, the total residential population and the scale of built-up spaces must adhere to a "rigid matching" principle. This hypothesis underscores an absolute correspondence between population and spatial capacity, asserting that the number of residents in a specific area must strictly align with the available spatial scale to achieve efficient resource utilization and rational spatial allocation. Deviations beyond established threshold intervals are theorized to trigger systemic risks, including resource mismatches, infrastructure vacancy, and economic decline (see Figure 1).

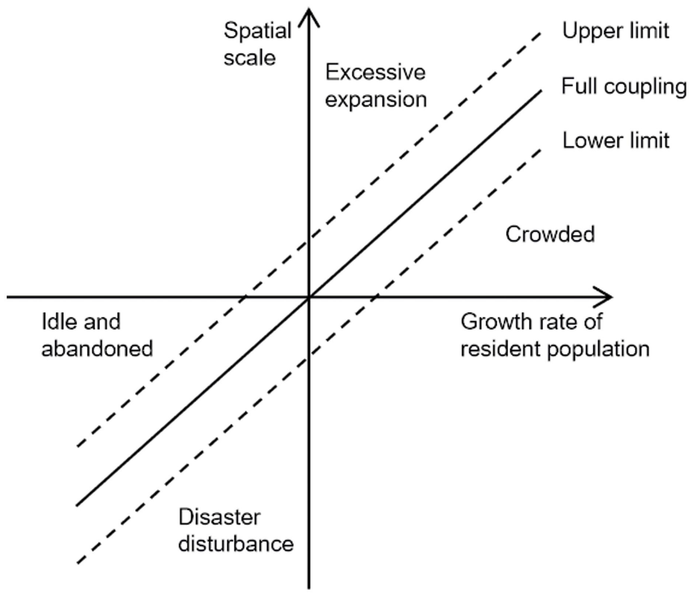

Figure 1 Traditional Resident Population–Built Space Coupling Model

To quantify such imbalances, scholars have introduced the Residential Population-Land Urbanization Index (α), defined as:

α = DR / LR

where α represents the coupling coefficient between residential population urbanization (DR, annualized change rate of population urbanization level) and land urbanization (LR, annualized change rate of spatial expansion). An α value of 1 indicates synchronized progression of population and land urbanization; α > 1 signifies spatial overexpansion relative to population growth, while α < 1 reflects population agglomeration outpacing spatial supply. Empirical evidence from international studies suggests that regions with sustained α values exceeding 1.2 consistently surpass the 15% critical threshold for vacant land ratios.

1.2 Efficiency Coupling Model

Building on traditional “aggregate coupling” principles, this study proposes a theoretical framework for the Residential Population-Built Space Efficiency Coupling Model. The framework posits that spatial efficiency can compensate for quantitative imbalances through resilient adaptation strategies—such as functional repurposing of spaces and adaptive reuse of structures—to maintain or enhance spatial performance despite population loss, thereby sustaining systemic viability in rural areas.

The efficiency coupling paradigm challenges traditional developmentalist approaches by prioritizing functional transformation and spatial innovation over population retention. Theoretically, it repositions built spaces as dynamic productive assets rather than passive containers. Practically, it offers innovative pathways for rural revitalization that transcend simplistic narratives of reversing population outflows.

2. Empirical Analysis: A Case Study of Huangyan District, Taizhou City, Zhejiang Province

2.1 Regional-Level Analysis

An analysis of the coupling relationship between residential population size and built-up area changes in Huangyan District from 2010 to 2020 reveals significant differentiation in coupling patterns across townships: Yutou and Maoshe Townships exhibited basic coupling, with slight synchronized growth in both population and built-up areas at comparable rates. In contrast, Shangzheng, Ningxi, and Tuotuo Townships displayed anomalous inverse revitalization patterns, contradicting field observations of spatial stagnation phenomena such as hollowing-out traditional villages and idle rural homesteads. The study hypothesizes that administrative seat towns may attract rural populations through spatial reproduction strategies—such as concentrated educational and medical resources or industrial park development—while ordinary villages continue to face persistent population outflows. To unravel this paradox, further investigation into the micro-scale dynamics of population and built-up space changes at the village level is required.

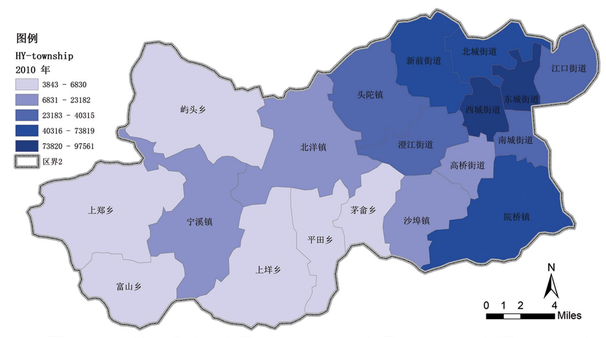

Figure 2a 2010 Permanent Resident Population

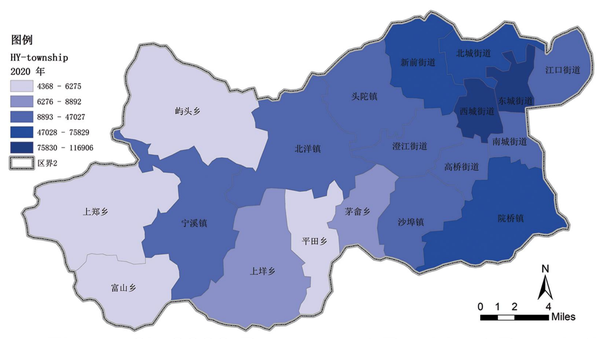

Figure 2b 2020 Permanent Resident Population

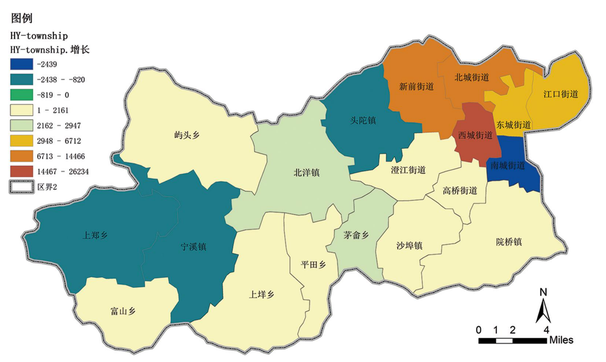

Figure 2c 2010–2020 Permanent Resident Population Change

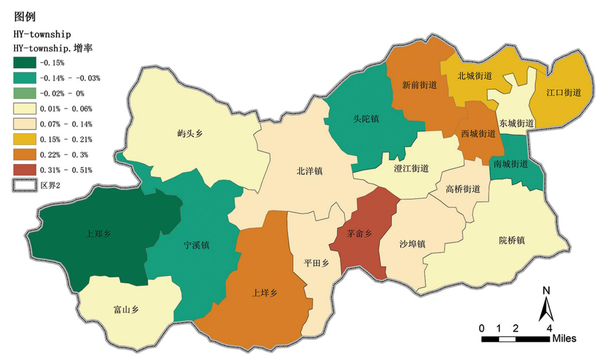

Figure 2d 2010–2020 Permanent Resident Population Growth Rate

Figure 2 Resident Population Statistics in Huangyan District

2.2 Village-Level Analysis

2.2.1 Development Overview of Shatang Village

Shatang Village in Huangyan District was historically a declining settlement plagued by population exodus. Accelerated regional urbanization triggered sustained outmigration of working-age residents, resulting in a hollowed-out demographic structure dominated by elderly populations, which further eroded community vitality. Public space systems deteriorated into disorder due to insufficient maintenance.

Since 2013, the Tongji University Huangyan Rural Planning team initiated the formulation and implementation of the Beautiful Village Plan for Shatang Village. During built environment optimization, planners adopted acupuncture-style interventions to repurpose vacant farmhouses into multifunctional community service facilities, preserving villagers’ spatial habits while integrating tourism functions. This spatial reproduction strategy effectively revitalized existing architectural resources, enhancing built space utilization efficiency.

2.2.2 Coupling Characteristics of Residential Population and Built Environment in Shatang Village

An analysis of residential population dynamics and built environment utilization efficiency reveals that over the past decade, despite the persistent decline in permanent residents due to urbanization, the functional efficiency of built spaces has paradoxically increased. This inverse evolution of population-space efficiency challenges traditional coupling models, which posit a linear correlation between population size and spatial utilization—where population shrinkage should theoretically reduce efficiency. Field investigations, however, demonstrate that through functional repurposing and spatial reproduction of vacant rural dwellings, traditional residences have been transformed into hybrid-use spaces, including cultural exhibition halls, maker workshops, and homestay clusters. These interventions have significantly enhanced the frequency of use and service capacity per unit of built space. Consequently, this “inverse revitalization” scenario aligns more closely with the residential population-built space efficiency coupling model proposed in this study.

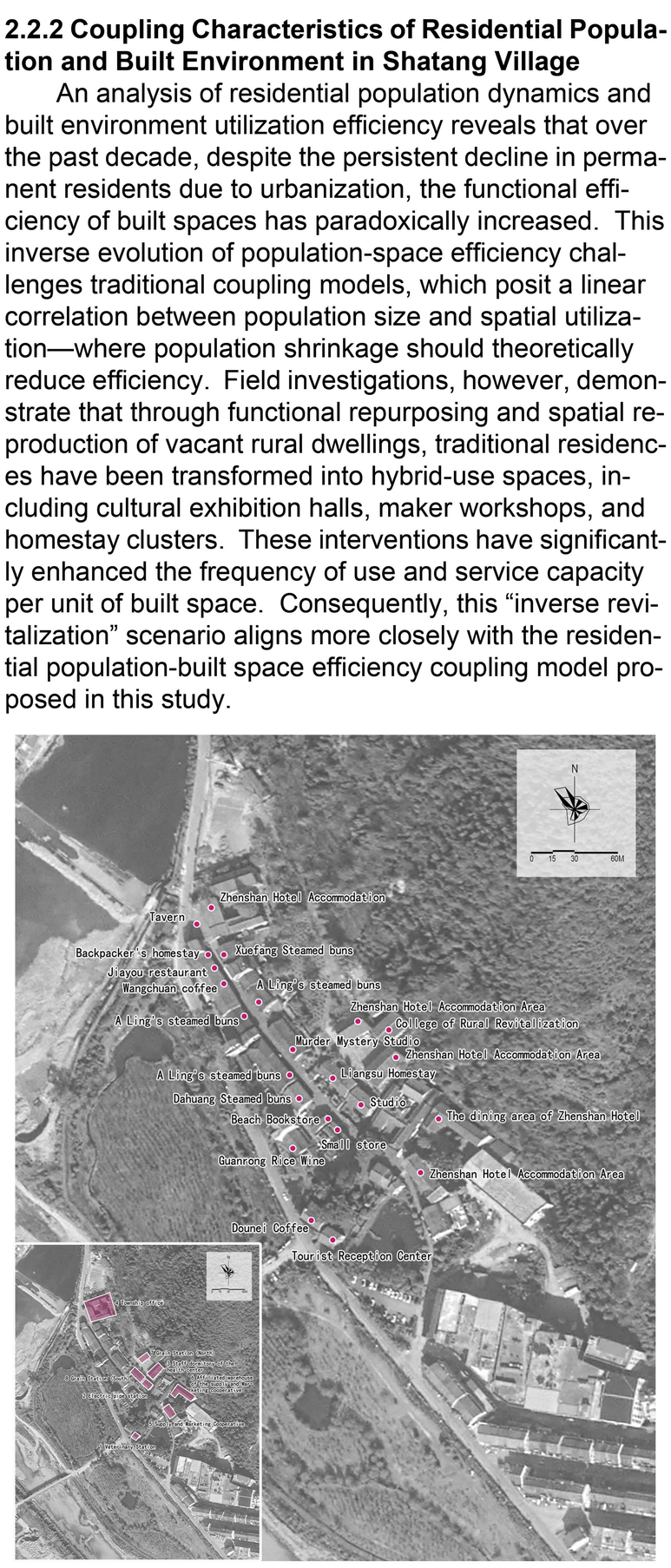

Figure 3 Spatial Distribution of Projects in Shatang Village