International Journal of Sociologies and Anthropologies Science Reviews
Volume 5 Issue 5: September-October 2025: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index

Study on Spatial Reconstruction Strategy of Dongshan Traditional Residential Buildings from the Perspective of Adaptive Design

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Received 12/06/2025 Revised 20/06/2025 Accepted 25/07/2025

Abstract

Background and Aim: This study focuses on the traditional dwellings of Dongshan, Suzhou.Dongshan's Ming Dynasty residences possess significant preservation value, cultural value, and academic research value. This study aims to explore how to protect and develop Suzhou Dongshan's traditional dwellings within the contemporary social context through adaptive design approaches, achieving a balance between cultural inheritance, historic preservation, and modern living requirements. Currently, there is a conflict between modern living requirements and the preservation of these historic spaces in Dongshan's traditional dwellings. Additionally, the aging and deterioration of the historic buildings make their conservation increasingly urgent. These problems have directly led to a large number of spontaneous renovations carried out by residents on their own houses within the village. This has resulted in the loss of the settlement's original cultural character, and the buildings themselves have been severely damaged. Most residents, during these alterations, considered only the convenience of daily life, neglecting the overall architectural character and features of the traditional dwellings.

Materials and Methods: Through methods such as field investigations, questionnaire analyses, and archival research, it explores their cultural history, architectural techniques, craftsmanship, spatial characteristics, and functional layouts, proposing design strategies adapted to modern needs. Among them, field surveys are used to record the spatial layout, questionnaire analysis is employed to understand the needs of contemporary users, and archival research is conducted to investigate the existing research achievements and the data on the cultural development of dwellings in the Dongshan area.

Results: This research has formed the spatial adaptive design theory of Dongshan traditional dwellings. By combining functional reconstruction with spatial adaptive design and using modular and standardized design methods without damaging the cultural texture, the practical achievements of spatial renewal design for Dongshan traditional dwellings have been formed. It constructs a spatial adaptive design guide for Dongshan dwellings in the modern context, realizing the spatial "re-adaptive design".

Conclusion: Based on the protection of traditional cultural elements, this study proposes renewal strategies that balance historical and modern needs, including the reconfiguration of functional spaces and the integration of modern facilities. These strategies achieve multifunctional adaptive design, promote the integration of traditional residential culture and modern housing design, and drive the innovative protection of traditional architectural heritage.

Keywords: Adaptive Design, Residential Architecture, Cultural Sustainability, Folk Culture Protection

Introduction

As a representative of folk architecture in the Taihu Basin within Jiangnan culture, Dongshan dwellings not only embody the unique historical and cultural imprints and folk-custom spatial types of this region but also feature abundant natural ecological landscapes. These residences have preserved many magnificent hall structures, whose cultural connotations and ritualized living patterns constitute a dynamic Dongshan dwelling culture, comparable to Ming Dynasty furniture in historical, scientific, and artistic values. Currently, research on Dongshan dwellings remains limited, lacking systematic academic discussions and artistic debates. Secondly, existing buildings face challenges such as material degradation, spatial layouts incompatible with modern lifestyles, and contradictions between heritage protection and functional adaptation, leading to disconnections in the practice of disseminating Dongshan culture in contemporary life. Thirdly, the spatial reconstruction of Dongshan dwellings lacks systematic design, damaging the stylistic characteristics of traditional architecture.

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Therefore, this study deeply considers the inheritance of traditional Dongshan dwelling cultural spaces and modern design reconstruction, combining adaptive design theory to achieve the continuity of the design culture and spirit of Suzhou Dongshan dwellings.

Objectives

The research objectives include the following 4 points.

1. Analyze the cultural and historical evolution of Dongshan vernacular dwellings.
2. Examine construction techniques and the Xiangshan craftsmen's influence.
3. Integrate traditional spatial aesthetics with modern residential needs.
4. Develop and apply adaptive design strategies for Dongshan houses.

Literature review

1. Analysis on the Evolution of Adaptive Design Theory

1.1 Conceptual Framework of Adaptive Design

Adaptive design refers to architectural strategies that enable buildings to dynamically respond to evolving environmental and societal demands within modern contexts. By integrating "adaptive design principles" with the typological characteristics of Dongshan vernacular dwellings, this approach seeks to establish a harmonious relationship between human activities and the built environment, offering development pathways that align with regional cultural identity, historical continuity, and contemporary needs. Pioneering ecological planner McHarg (1992) asserted that "all natural forms are products of adaptation; similarly, all human-made forms, including architecture and cities, should be created and evaluated through the lens of adaptability." In addressing the spatial adaptation of vernacular architecture, Kieran and Timberlake's Refabricating Architecture (2005) provides a foundational argument for manufacturing methodologies as catalysts of transformative building practices. Their work underscores how prefabrication and modularity, traditionally associated with industrial efficiency, can enhance spatial adaptability while reducing environmental impact (Kieran & Timberlake, 2005). Dohotariu (2021) further examined the role of technology in adaptive architecture, emphasizing how advanced sensors and smart materials enable real-time environmental responsiveness, thereby enhancing occupant comfort and energy efficiency.

Building on this theoretical foundation, the analysis not only reaffirms McHarg's (1992) principle that "Design Should Follow Nature," but also establishes the critical importance of modular design methodologies in addressing adaptive challenges within Dongshan vernacular dwellings. Furthermore, the integration of contemporary materials and technological interventions demonstrates significant potential to enhance the environmental acclimatization capabilities of traditional residential structures while preserving their cultural essence.

1.2 Development of Adaptive Design in Contemporary Contexts

In modern practice, adaptive design principles are intrinsically linked to sustainability goals. Konieczna (2018) analyzed emerging trends in adaptive architecture, highlighting the use of dynamic housing configurations and flexible spatial forms to address fluctuating environmental conditions and user requirements. Huang (2024) introduced the concept of "Rhythmic Buildings," advocating for a systems-thinking approach to embed adaptive design within broader sustainability frameworks, aiming to tackle global challenges such as climate change and resource depletion. The evolution of adaptive design in contemporary discourse reflects a synthesis of sustainability imperatives, technological innovation, and functional optimization, ultimately striving to create architectural spaces capable of adapting to dynamic ecological, social, and cultural shifts. Similarly, in the modern context, the adaptive design theory also faces challenges and limitations such as the risk of technological dependency or the operational complexity of integrating new systems into existing structures.

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2. Analysis and Research on the Regional Cultural Adaptability of Dongshan Vernacular Dwellings in Suzhou

2.1 Development of Dongshan's Regional Cultural Identity

The evolution of vernacular regional culture hinges on geographical, social, and historical factors. Dongshan vernacular architecture stands as the dominant type among historical buildings in the area, showcasing unique local traits in scale and cultural expression.

Geographically, Dongshan has a temperate monsoon climate. Summers are humid and rainy; winters are cold and dry. The annual average temperature is 16°C, with about 1,100 mm of precipitation, 40% of which falls in summer. Winter temperatures rarely drop below zero.

Architecturally, Dongshan buildings usually have front and rear courtyards (Tianjing), floor-to-ceiling windows, and low-sill fenestration. Their steep roofs aid drainage. Empirical research by Sui (2006) shows that in Suzhou's traditional shallow-depth layouts, enclosed courtyards can lower summer temperatures by nearly 10°C compared to the outside, greatly enhancing thermal comfort. (Sui, 2006).

2.2 The coordinated development of Shang-Confucian culture and residential culture

The literati showed their personal nature by planning stone and landscape in the residential buildings. Wang Ao, Prime Minister (1506-1509) during the reign of Zhengde in the Ming Dynasty, built "Huihe Hall" in Dongshan Luxiang Village after he resigned from office (Figure 1).

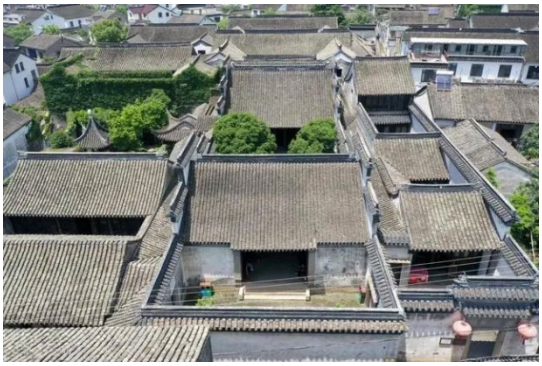

Figure 1: Aerial view of Huihe Hall

Over thousands of years, Confucian culture has been a dominant force in ancient Chinese thought. Dongshan vernacular architectural culture closely aligns with Confucian principles, evident in its regular layouts, hierarchical order, and ethical symbolism. Confucianism underpinned feudal class structures based on patriarchal clan systems (Zongfa) and familial ethics.

Suzhou, as the economic hub of Jiangnan, thrived due to Hui merchants. These merchants traded timber, tea, and other resources from Huizhou. According to Tang & Shen (2004), "Hui merchants actively shaped Suzhou's urban growth, stabilizing the economy and promoting cultural prosperity. Local records document their philanthropy, such as funding bridges and public works". This trade solidified the Hui merchants' settlement in Suzhou, forming lasting socio-economic networks. Confucian culture has also become an important driving factor for the adaptive development of residential space. (Figure 2)

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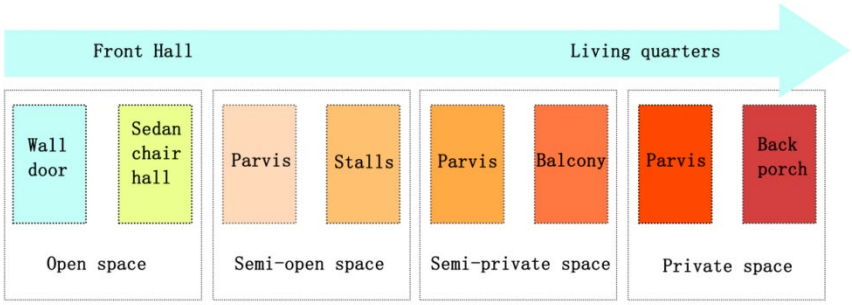

Figure 2: The spatial layout of the influence of Confucian culture

2.3 Respect nature and conform to nature in the form and layout of residential villages

Vernacular villages represent fundamental socio-spatial constructs shaped by collective human activities, integrating economic, transportation, political, and cultural dimensions. As the elemental unit of these villages, vernacular architecture embodies the material realization of a community's intentional design to create idealized living spaces (Figure 3). Humans, as the primary agents within these structures, exhibit varying morphological characteristics across temporal and spatial contexts, evident in traditional residential spaces, alleyway networks, and town-village interfaces. From site selection and spatial organization to individual building design, these forms consistently reflect the principles of adaptation to local materials, contextual responsiveness, and topographic integration. As noted by American vernacular architecture scholar Christopher Alexander: "Architectural character is determined by recurring patterns of life within a specific context - a synthesis of human activities and environmental constraints" (Shan, 2004).

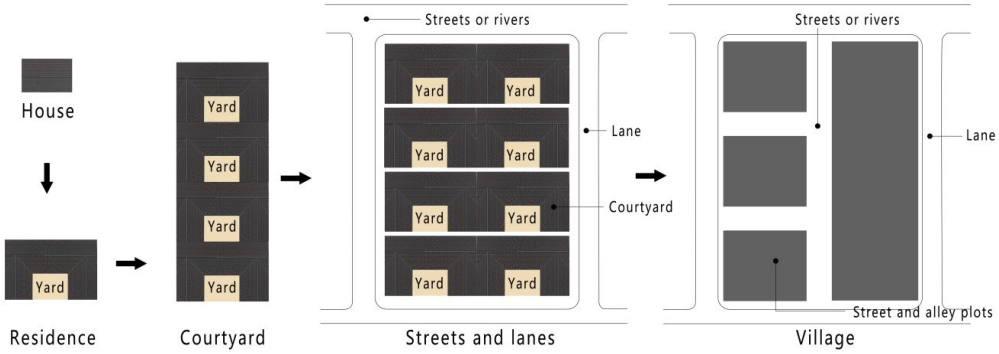

Figure 3: Evolution map from residential houses to villages

Over 4,000 years ago, Dongshan in Suzhou existed as an isolated, primitive clan settlement where communities subsisted on fishing and hunting. Later, "influenced by Central Plains cultural practices, residents began supplementing their livelihoods with animal husbandry and agriculture, while some migrated to terrestrial settlements". With population growth and commercial expansion, by the early Jiajing era of the Ming dynasty (1522–1566), "the Dongshan and Xishan regions housed 18,085 households and 99,971 inhabitants" (Xue, 2005), imposing immense pressures on local resources. This compelled peasants to engage in market trade for daily necessities, simultaneously driving socio-economic development and the systematic construction of villages and towns. Settlement morphology prioritized strategic environmental adaptation, exemplified by principles such as Beishan mianshui (backing mountains, facing water), Fuyin baoyang (embracing shade while holding sunlight). These practices optimized natural topography to maximize sunlight exposure while mitigating winter winds and summer humidity. Vernacular villages in Dongshan - including Luxiang Village, Yangwan Village, and Wengxiang Village - evolved organically around the island's hilly terrain, reflecting adaptive integration with mountainous landscapes (Table 1). Similarly, due to its warm and humid climatic conditions, prosperous living

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foundation, and developed handicraft industry, the Dongshan area in Suzhou has also become an ideal place for literati and scholars to choose their living environment. Located in mountainous areas, it is rich in building materials such as bricks and stones, in addition to timber. In terms of agricultural products, the Dongshan area is also abundant in fruits, fish, shrimp, vegetables, and other agricultural and sideline products, with rice as the main dietary staple. From the perspective of agricultural culture development, production, and life in the Dongshan area all revolve around "water". The types of dwellings also form different scales due to factors such as the owner's economic situation, social differences, and topographical bases, such as single-courtyard dwellings and multi-courtyard dwelling combinations.

Table 1: List of folk villages in the Dongshan area

No.	Place Names	Village morphology	Village graphics
1	Dongshan Ancient Town	Uniform space, ladder-like layout	
2	Lu Xiang Village	Near lakes, clumpy distribution	
3	Yangwan Village	Fishbone-shaped space	

2.4 Small family social structure and residential form space of Dongshan folk houses

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Despite its geographic isolation, Dongshan experienced outward migration driven by population pressures and resource scarcity. Residents engaged in commerce or pursued imperial examinations, fostering regional economic growth and cultural advancement - a stark contrast to the insularity of the Huizhou region. The rise of a commodity economy gradually eroded the patrilineal clan system (zongzu zhidu), shifting societal structures toward nuclear families. By the Ming-Qing period, small households dominated Dongshan's social fabric, with only a few large clans remaining. This underscores how economic foundations, rather than cultural preferences, shaped Dongshan's vernacular architecture and social dynamics.

Clan-based residential complexes typically expanded from a square or rectangular core, subdivided hierarchically as families grew. Large mansions featured four-courtyard layouts (si jin) or more, separated by walls and interconnected by skywells. According to Yingzao Fayuan, "Structures along the central axis are termed zhengluo (main halls), while flanking buildings - bianluo (side halls) - house studies, parlors, kitchens, and servant quarters" (Yao, 1986). The axial symmetry emphasized centrality, with zhengluo and bianluo linked by beilong passageways (serving as circulation corridors). Mid-sized and small dwellings adopted three- or two-courtyard configurations, while modest homes often had a single courtyard.

3. Adaptive Craftsmanship in Dongshan Vernacular Architecture

3.1. Structural form and technological characteristics of large woodwork

Influenced by the Xiangshan School, Dongshan's vernacular architecture uses traditional timber framing. Columns, beams, fang (Tie-beams), and purlins interlock to create a stable structure. Columns, usually made of pine or fir, bear vertical loads, with their layout and size varying by building scale and function. Beams span horizontally between columns to transfer roof loads. Fang connects joints to enhance stability, and purlins rest on beams to support rafters.

The mortise-and-tenon joint (Sunmao) is key to Dongshan's timber craftsmanship (Figure 4). This nail-and-bolt-free technique uses interlocking grooves and protrusions. It strengthens structural integrity and seismic resistance, showcasing expert woodworking. Common types include:

Straight tenons (Zhi sun): Simple yet strong column-beam connections.

Corner tenons (Chajiao sun): Angled joints for stability at corners.

Interlocking tenons (Chuansuo sun): Multi-layered joints for complex framing (Figure 5).

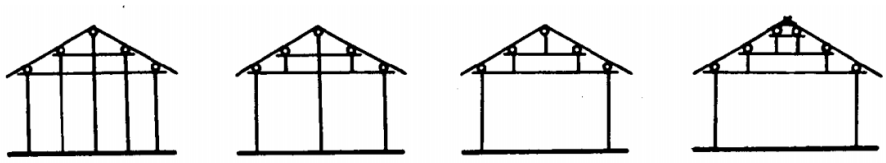

Figure 4: A perspective view of the lifting beam roof truss

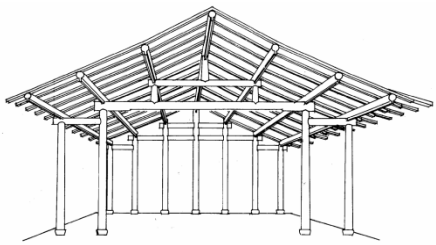

Figure 5: Diagram of the basic form of a beam frame

3.2 Structural form and technological characteristics of small woodwork

The door and window structures of Dongshan vernacular architecture showcase the ingenuity of traditional joinery. They integrate functional and decorative elements, similar to furniture, partition panels, staircases, and railings. Composed of slender wooden battens, door and window frames consist of key parts:

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frames, leaves, and lattices, joined by mortise-and-tenon techniques for a sturdy yet flexible build. Door leaves and window lattices feature openwork carvings. These carvings, depicting flora, fauna, and auspicious symbols, serve dual purposes: enhancing ventilation and lighting while expressing cultural wishes for prosperity. Lattice designs vary from simple lines to complex geometric or traditional patterns, adding visual interest.

Partition panels (Geshan) divide spaces and decorate interiors. Screen panels (Pingfeng), often multi-paneled with elaborate carvings or calligraphy, exhibit high artistic value. Their modular design allows for flexible interior reconfiguration, balancing privacy and adaptability. As Qing-dynasty scholar Qian Yong stated, "Carving craftsmanship was widespread, with Ningguo, Huizhou, and Suzhou leading in output and technical excellence" (Qian, 1998). Traditional joinery, with its clever structures and rich ornamentation, represents the skill and cultural depth of ancient Chinese artisans.

3.3 Tile stone structure form and craft characteristics

In the traditional residential houses of Dongshan, Suzhou, the tile and stone structure, as an important part of Xiangshan Gang construction skills, shows the unique style and cultural connotation of Ming Dynasty architecture. Tile structure is a structural form with tile and stone as the main building materials, which has profound expression from the aspects of bearing structure, spatial layout, and decorative style. The main feature of the tile structure is that the roof is covered by green tile (Figure 6), and stone is used as the construction material for the wall and base, which not only enhances the durability of the building, but also enhances the durability of the value. In addition, it can effectively resist the rainy climate in Suzhou. From the perspective of tile and stone structure, it is mainly composed of seven aspects: foundation, platform, paving, plinth, roof, house body, and roof.

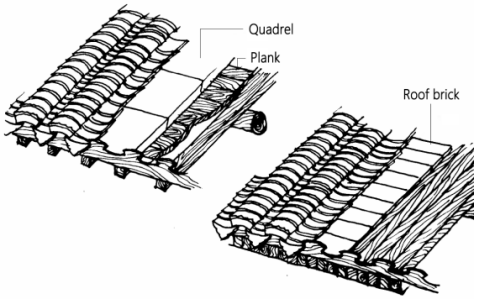

Figure 6: Roof tile structure

This paper discusses the timber framing forms, including modular mortise-tenon joints, eave tile configurations, and other structures, which exhibit certain detachable properties. These features preserve the capability for future renovation and restoration of modern residential buildings, also emerging as one of the contemporary adaptive design forms.

4. Space design aesthetics and modern life demands of traditional folk houses in Dongshan, Suzhou

As a quintessential vernacular form in Suzhou during the Ming and Qing dynasties, Dongshan residences face evolving challenges and opportunities in functionality and adaptability amid modern demands. According to Yingzao Fayuan, the traditional layout of Suzhou dwellings progresses inward from the main gate to the tea hall, main hall, and upper hall, followed by either a boundary wall or a wandering garden at the rear (Hou & Hou, 2014). The axial symmetry, front-rear courtyard sequence, and multi-courtyard depth of Dongshan residences historically accommodated extended families and reinforced Confucian hierarchies. Axial symmetry emphasized ritual order and social stratification, while courtyards provided communal spaces and scenic vistas. Layered depth enhanced spatial privacy and symbolic progression, reflecting the interplay of family ethics and spatial logic.

Despite these historical imperatives, Dongshan's architectural aesthetics, rooted in harmony with nature and cultural symbolism, retain profound relevance for contemporary design. As philosopher Li Zehou noted: "Unlike Western aesthetics, which prioritizes systematic logic, Chinese tradition embraces intuitive perception - beauty resides in emotional and spiritual resonance rather than rational explication"

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(Li, 1986). This unity of functionality and aesthetics offers a vital reference for adaptive reuse, embodying ideals of humanistic living and the regional ethos of Dongshan. Such regionally grounded, emotionally resonant spaces continue to inspire diverse interpretations of vernacular life.

The residential buildings in Dongshan, Suzhou, were designed with the living needs of residents in mind, ensuring that the structures are not only aesthetically pleasing but also highly practical. For instance, the courtyard layout is both visually appealing and functional, ensuring adequate lighting and ventilation. The interior decoration combines aesthetic appeal with practicality, creating a living space that is both comfortable and artistically rich. This harmonious blend of functionality and aesthetics not only provides valuable insights for the adaptive design of modern residences but also embodies the noble ideals of residential life and the cultural spirit of the Dongshan region.

Methodology

1. Field research method: A systematic on-site research method was adopted. We went to the Dongshan area of Suzhou and conducted on-site investigations, mappings, real-scene photo shootings, etc. of representative residential buildings in the Dongshan area of Suzhou, collecting first-hand information on aspects such as building structure, decorative details, and material application. Select existing historic protected buildings in the area, such as Huihe Hall, and make detailed measurements, including hand-drawn sketches and measurements using tools such as laser rangefinders, to ensure that information on structure, materials, and spatial layout is collected consistently.

2. Literature analysis method: By consulting historical documents, architectural drawings, library book resources, and other related research results, we systematically sorted and analyzed the historical background, construction techniques, characteristics, and artistic styles of the Ming Dynasty residential buildings in Dongshan, Suzhou. This enables an in-depth and comprehensive understanding of the cultural connotation and historical context of the Ming Dynasty residential buildings in Dongshan. This process provides academic support for the theoretical framework and adaptive design of the research. In the process of research, thematic analysis was used to identify recurring themes, controversies, or knowledge gaps in Dongshan architecture. The architectural techniques analyzed from historical documents were cross-verified with the results of field studies to confirm the accuracy of history and identify changes over time.

3. Questionnaire method: Questionnaire research was conducted from two aspects. The first part was for local people in the Dongshan area and the Xiangshan Gang artisans. The questionnaires covered folk culture, living space, etc., aiming to analyze the adaptability of traditional residential space in modern life. The questionnaire survey employs a combination of stratified and random sampling. First, the population is divided into different levels based on the research objectives, including demographics (residents, tourists) and age groups (different age ranges). Within each level, a certain number of samples are selected using random sampling to ensure the representativeness and diversity of the sample.

This study established corresponding scoring criteria for the questionnaire design. The questionnaire uses a 4-point Likert scale, with options assigned values of 4, 3, 2, and 1, respectively, to accurately quantify respondents 'attitudes toward each question (Table 2). Most questions in the questionnaire, such as understanding of the cultural history of Ming Dynasty residential buildings, knowledge of building materials, and evaluation of spatial layout rationality, have four options, ranging from positive to negative and from deep to superficial. For example, regarding' Your level of understanding of the cultural history of Ming Dynasty residential buildings in Suzhou Dongshan, 'the options are:' A. Very familiar, with professional knowledge ',' B. Some familiarity, able to describe main features but without professional knowledge ',' C. Only roughly known, heard, or briefly contacted ',' D. Completely unfamiliar'. These options clearly define a cognitive gradient from high to low. The questionnaire includes 22 questions, both multiple-choice and open-ended, covering four aspects: basic information about residents and tourists, life experiences, understanding of residential space, and methods of residential renovation, to comprehensively understand the needs of residents and tourists.

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Table 2 Rating Criteria for Assessment Analysis Score Level Values

Score level	Meaning of appropriate level
4	Suitability is at a very good level.
3	Suitability is at a moderate level.
2	Suitability is at a very low level.
1	None

4. Mixed research method: Combining qualitative and quantitative analysis, through comprehensive historical analysis, on-site research, questionnaire survey, and expert interview results, a comprehensive evaluation of the cultural value, functional adaptability, and aesthetic effect of the design scheme was conducted. In a convergent design, qualitative and quantitative data are collected and combined for analysis. Quantitative data are collected first, and then the initial results are explained through qualitative data. Historical analysis and field investigation will establish cultural values, and questionnaire results will provide information on functional adaptability, both of which will work together.

Results

1. Constructing an Adaptive Renewal Framework Integrating Cultural-Functional Synergy in Dongshan Vernacular Architecture

Based on the theory of adaptive design research, this study investigates the cultural development and regional characteristics of Dongshan vernacular dwellings in Suzhou, along with their construction techniques, design aesthetics, and the living needs of residents. It establishes an adaptive research framework that achieves organic integration between cultural preservation and functional transformation in Dongshan dwellings. (Figure 7)

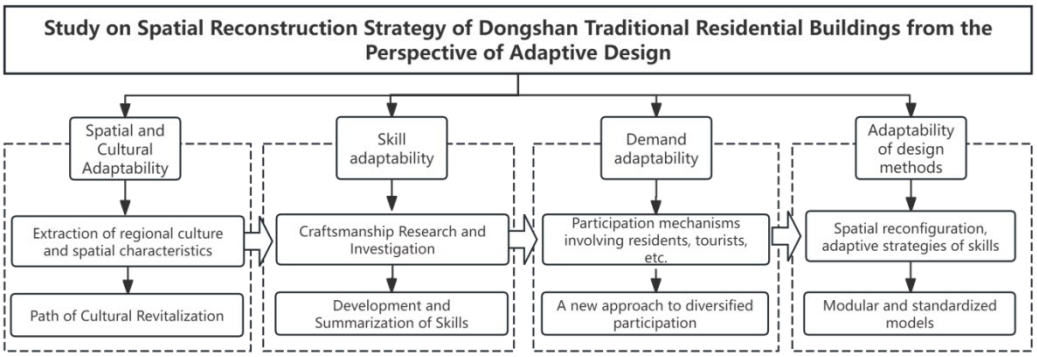

Figure 7: The picture is the adaptive renewal framework of the cultural and functional combination of Dongshan folk houses.

The research framework, in line with the target system of adaptive design, analyzes the regional culture of Dongshan dwellings to extract their developmental characteristics. From the perspectives of spatial-cultural adaptability and craftsmanship adaptability:

Spatial-Cultural Adaptability: The Ming Dynasty dwellings in Suzhou Dongshan serve as material testimonies to the social-economic prosperity of Jiangnan in the Ming Dynasty, and are the product of regional culture, familial systems, craftsmanship, and ecological environment.

Craftsmanship Adaptability: Traditional architectural techniques in adaptive design act not only as restoration methods but also as symbols of cultural regeneration, enabling traditional dwellings to coexist with modern society while maintaining cultural roots and upgrading living spaces and structures.

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Needs Analysis: The spatial organization of Dongshan dwellings emphasizes hierarchy and ritual, adopting a "front hall-rear bedroom" symmetric layout with public halls on the central axis and residential side rooms, providing references for modern residential design.

Design Methods Adaptability: It summarizes spatial configurations (e.g., axial layout, multi-courtyard spaces) and functional zoning connected by courtyards/patios, forming a spatial feature of "clear internal-external boundaries and ordered dynamic-static separation". Based on this, it designs courtyard units that balance contemporary living needs and traditional cultural inheritance.

1.1 Research on residential buildings in Dongshan

Ming Shan Tang, located in Yangwan Village, Dongshan Town, Suzhou City, was constructed during the late Ming Dynasty. It is a medium-sized residential building with four courtyards and a total construction area of approximately 570 square meters. The layout of Ming Shan Tang is well-organized, situated close to the street. From the floor plan, it can be seen that Ming Shan Tang is divided into two main sections: the eastern part, which includes the flower hall, main hall, garden, and side passages; and the western part, which features the main gate, living room, Buddha pavilion, warehouse, kitchen, guest hall, and garden. Each courtyard is separated by a sky well, with a total of 15 sky wells of various sizes. Ming Shan Tang is renowned for its wood carvings, stone carvings, brick carvings, and paintings, featuring traditional folk themes such as blessings and auspiciousness. The gate tower measures 3.44 meters wide and 6.4 meters high, and its brick carvings are outstanding examples of brick carving art from the Ming and Qing Dynasties. The main hall has a gable roof, measuring 21.45 meters wide and 12.32 meters deep; the flower hall is 10 meters wide and 7.45 meters deep with a corridor. The Buddha pavilion, located west of the main hall, is 5.4 meters deep with a corridor and 7.3 meters wide. Inside, Ming Shan Tang is lavishly decorated, making it an excellent representative of the Ming Dynasty residences in Dongshan, with significant research value (Figure 8).

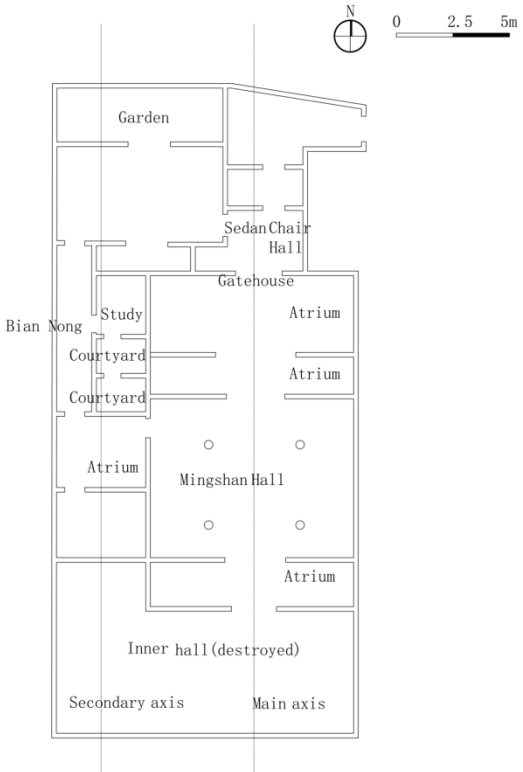

Figure 8 Mingshan Hall layout

Citation
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International Journal of Sociologies and Anthropologies Science Reviews
Volume 5 Issue 5: September-October 2025: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index

Huihe Hall, located in Luchang Village on Dongshan Island in Suzhou, began construction in the late Ming Dynasty and was completed during the early Qing Dynasty. It is a large residential building with a 'five-entry' courtyard layout, covering an area of about 5000 square meters with a building area of 3000 square meters. It was the former residence of Wang Ao, a Ming Dynasty prime minister. The courtyard is divided into three main axes: the central axis, the left axis, and the right axis. The main buildings include the gate tower, sedan hall, main hall, hall tower, rear building, and rear garden. On the left axis are the flower hall, living room, book tower, and small garden. On the right axis are the door room, tea hall, kitchen, miscellaneous rooms, and side building. Both sides of the courtyard are connected by long alleys, and the middle sections are separated by sky gates, stone gates, and fire walls. The corridors and windows are intricately crafted, and the beams and pillars are made of sturdy materials, mostly nanmu. The main buildings along the central axis of the hall were constructed during the Qing Dynasty, while the western part, including the book tower and screen wall, is the former residence of Wang Ao, which dates back to the Ming Dynasty. (Figure 9)

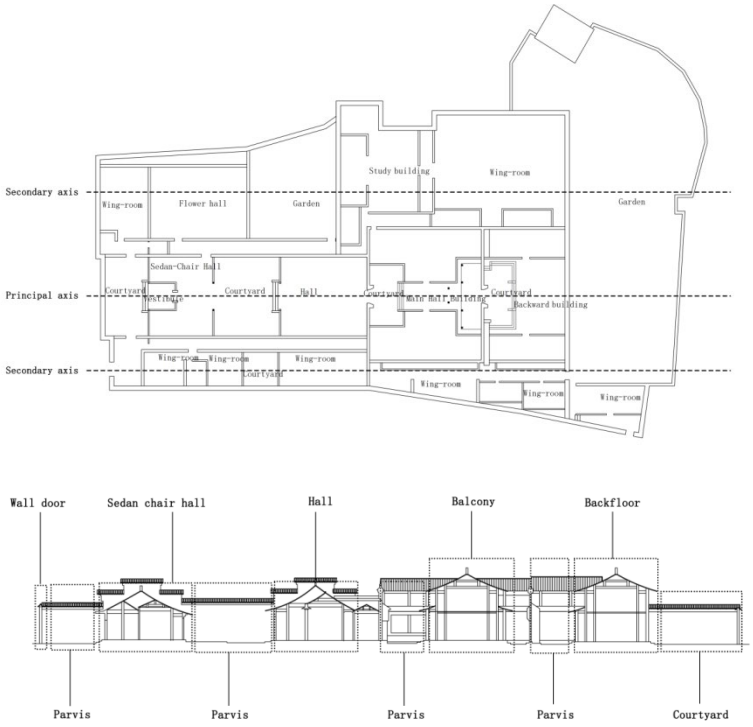

Figure 9 Huihe Hall layout

1.2 Dongshan residential space form

The spatial scale of the Dongshan residential buildings influences people's living behaviors and reflects the cultural characteristics of the Suzhou region. The renowned Japanese architect Yoshinobu Ashihara proposed that architecture is not merely a combination of physical spaces but also a sensitive response to human psychology and emotions. He offered numerous insights on scale, space, and human psychology, emphasizing that the scale of buildings should align with their functions, and different spaces for various functions should have distinct scale requirements. The Dongshan residential buildings, whether in terms of external or internal spaces, aim to enhance the overall sense of the building, creating a residential space that is both welcoming and in line with people's living habits. He suggested that the reference formula for spatial scale should be divided into several ranges:

$$D/H < 1,\quad D/H > 1,\quad D/H=1,\quad D/H > 4$$

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The relationship between building height (H) and the distance from adjacent buildings (D) is such that when D/H <1, a sense of pressure is felt; when D/H> 1, a sense of distance is felt; when D/H = 1, the relationship between building height and spacing is most comfortable; and when D/H> 4, there is no reference or objective relationship between the buildings. (Ryuwa Yoshinori, 2017) We can also use the ratio of D to H to calculate the proportional relationships between buildings within the Dongshan residential area, designing spaces that feel comfortable. For example, in the Ming Shan Hall, the widest part of the alley next to the Ming Shan Hall is about 2-3 meters, and the narrowest part is 1.5 meters. The gable walls on both sides of the alley are over 3 meters high, so D/H <1, making the space feel narrow and enclosed. In the courtyard, D/H> 1, providing a more comfortable and open recreational space (Figure 4.10).

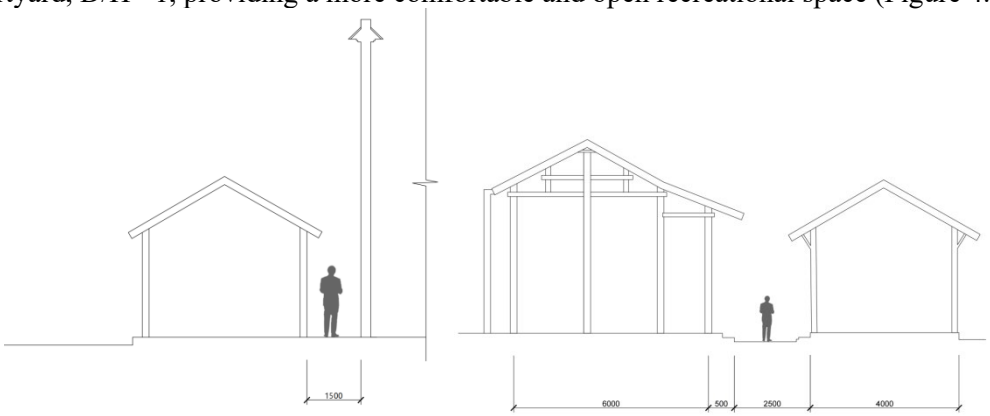

Figure 10 Spatial scale analysis of residential street

2. Study on spatial reconstruction strategy of traditional residential houses in Dongshan from the perspective of adaptive design - a case study of residential houses in Luxiang Village

2.1 Project Background

The project site is located in Luxiang Village, Dongshan Town, Suzhou. It is one of the villages with the largest number and highest quality of preserved traditional residential buildings in the Dongshan area. Backed by mountains and facing water, with a higher elevation in the east and a lower one in the west, Luxiang Village is known for its picturesque scenery and serves as a typical model of a "pastoral-style tourism-oriented new countryside."

2.2 Requirement research and analysis

According to the formula of stratified sampling and random sampling sample size: n=(p*q) z2/e2, the sample size of the obtained survey data is the sample size. Where z is the standard error corresponding to selected confidence level, which is generally 1.96; p is the estimated percentage in the population, set to 95%; q=100%-p; e is the allowable error, that is, the error ratio of the total estimated sample that can be received, set to +2.7%, and specific sample size is calculated as follows:

$$n = \frac{(p * q)z^2}{e^2}$$

According to the sample size research formula, the sample size of this survey questionnaire is not less than 250. Reasonable selection and calculation of the sample size also ensure the accuracy and feasibility of the research results.

A total of 251 valid survey data were received through the final survey, and the survey data were analyzed as follows (Table3):

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Table 3 Data Analysis Table of Residents and Tourists Survey

No.	Survey contents	Statistics (number of people)	Percentage (%)	Analysis conclusion
1	Age distribution of respondents	Ages 18-30 :23 31-40 :66 41-50 :120 51-60 :42	8.4% 24.1% 43.7% 15.3%	The respondents are mainly young and middle-aged, with a certain cultural cognition foundation, and pay attention to the protection of residential buildings.
2	Identity of the interviewees	Local residents: 125 Tourist: 126	49.8% 50.2%	Local residents and tourists are equally concerned, and adaptive design needs to take into account needs of local living and tourism.
3	The degree of cognition of Dongshan folk culture	Very well understood: 37 Basic understanding :51 Less understanding :103 Not at all :60	13.5% 18.6% 37.6% 21.9%	The public's awareness of folk culture is low, so it is necessary to strengthen publicity and education to improve the sense of identity.
4	The most representative cultural characteristics	Architectural style: 84 Family history :35 Folk culture :106 Traditional customs :26	30.6% 12.7% 38.7% 9.5%	Cultural cognition is mainly focused on architectural style and folk culture, which should be highlighted in future conservation.
5	Whether to support the protection of folk houses	Support :180 Neutral :50 Unsupported: 21	75.3% 20.9% 3.8%	The society has a high degree of recognition for the protection of residential buildings, and specific protection measures need to be optimized.
6	Folk houses adapt to modern life level	Full adaptation :60 Partial adaptation :160 Maladaptation: 31	22.7% 60.6% 11.7%	Adaptive design still needs improvement to improve living comfort and modern functionality.
7	Protection measures of primary concern	Government policy support :145 Traditional craft inheritance :78 Residents' independent maintenance :28	56.1% 30.2% 10.8%	The protection mechanism should combine government policy support with the inheritance of traditional crafts to enhance residents' participation.
8	The most desirable spatial elements for improvement	Daylighting :103 Ventilation :90 Interior layout :64	40.2% 35.1% 24.7%	The future design needs to improve lighting and ventilation conditions of the residential buildings to improve living comfort.
9	Leading the main body of conservation work	Government :160 Community :62 Individuals :29	62.3% 24.1% 11.3%	Conservation efforts should be government-led, with the participation of communities and individuals.
10	Expectations for the future direction	Combined cultural tourism:193 Preservation of original appearance:38 Modern functional transformation:20	75.5% 14.9% 7.8%	Cultural tourism and original preservation need to be balanced to avoid over-commercialization or damage to cultural values.

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The above data show that the public's evaluation of the overall protection effect is general, and they think that the adaptability of folk houses in modern life is reasonable but needs to be improved. There is a strong voice for promoting the spread of cultural values, improving tourism facilities, and holding activities, and most people are willing to participate in the protection and inheritance. The government is regarded as the main responsibility for the protection, and most people expect moderate transformation to promote its development. This research provides an important public opinion reference for the protection and adaptive design of the Ming Dynasty residential buildings in Dongshan, Suzhou, and more targeted strategies can be formulated accordingly.

The research findings indicate that the study should be designed from several perspectives: the inheritance of regional culture, knowledge, and cultural cognition, traditional skills and modern applications, spatial function improvement needs, and aesthetic and environmental protection. During the design process, the spatial types, construction techniques, aesthetic expressions, and adaptive design practices of the Ming Dynasty residences in Dongshan, Suzhou, should be fully integrated. First, priority should be given to improving thermal comfort and visual comfort. In the adaptive design strategy, larger windows, skylights, or the reconfiguration of internal partitions should be prioritized without compromising the historical characteristics of the buildings. Second, the design solutions should celebrate and interpret the unique architectural style and traditional craftsmanship of Dongshan visually, while considering the integration of modern facilities and enhancing the connection between residential living spaces and public spaces.

2.3 Overall planning of design scheme

2.3.1 Spatial Renewal Design of Traditional Dwellings through Modular and Standardized Strategies

Through an in-depth analysis of the regional characteristics, cultural context, and construction techniques of Dongshan traditional dwellings, a theoretical framework for adaptive spatial design has been formulated. This framework provides a technical pathway for inheritance and protection of Dongshan's residential cultural heritage. Form and spatial organization of architecture are determined by the lifestyle of its inhabitants; architecture is, in essence, a direct expression of human ways of living (Zhang, 2005). The overall spatial layout of traditional residential design in this study aligns with the existing stylistic and geographical context. It is grounded in the traditional lifestyle of local residents while addressing the behavioral patterns and spatial needs of diverse user groups. Design emphasizes interaction between private living spaces and shared public areas, resulting in a modular, diversified, and adaptable residential environment that balances tradition with modernity. Given that contemporary households typically follow the "one family per dwelling" structure, the project, under the premise of meeting modern living demands, develops four types of residential design units based on the continuous evolution of traditional housing (Figure 11). The interior space organization is redefined by privacy needs, transforming traditional functional areas into multifunctional spaces suited for contemporary life.

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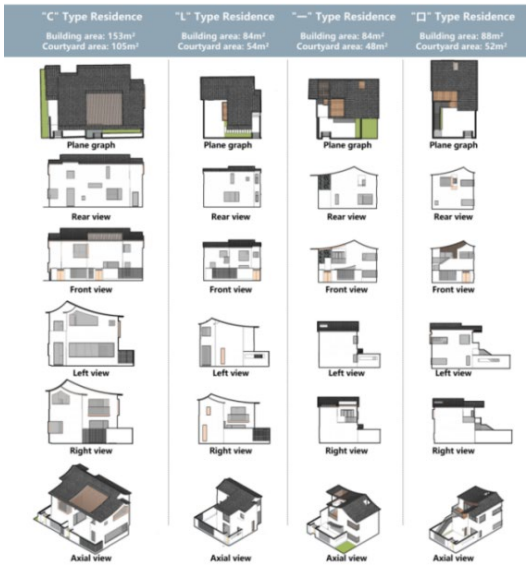

Figure 11: Four kinds of residential courtyard space units

The four courtyard types include the “C”-shaped, “L”-shaped, “I”-shaped, and “square” (enclosed) configurations. These layouts cater to different household needs, all designed as two-story structures. Among them, the “C”-shaped courtyard is the largest, with a single-floor area of 153 square meters and a courtyard area of 105 square meters. It incorporates a central atrium to maintain traditional ventilation and lighting while preserving the spatial typology of Dongshan dwellings. The “L”-shaped unit has a single-floor area of 84 square meters and a courtyard of 54 square meters; the “I”-shaped layout covers 84 square meters with a 48 square meter courtyard; and the “square” unit offers 88 square meters of interior space with a 52 square meter courtyard. All four types adopt large window openings to meet natural lighting needs and to address the dim interior conditions often found in traditional residences. In the design, the original front hall is transformed into a modern living room or multifunctional activity space to support everyday family life and social interactions. The courtyard is reimagined as an open shared space for gatherings, dining, or other social functions. These transformations not only preserve the historical and cultural essence of traditional residential space but also enable it to meet the diverse demands of contemporary lifestyles (Figure 12). Such a transformation not only retains the historical and cultural connotation of the space, but also makes it adapt to the diversified needs of modern life (Figure 8). The multi-functional living space not only meets the residents' demand for spatial flexibility in the research process, but also allows different residential units to be freely combined to form a larger residential group.

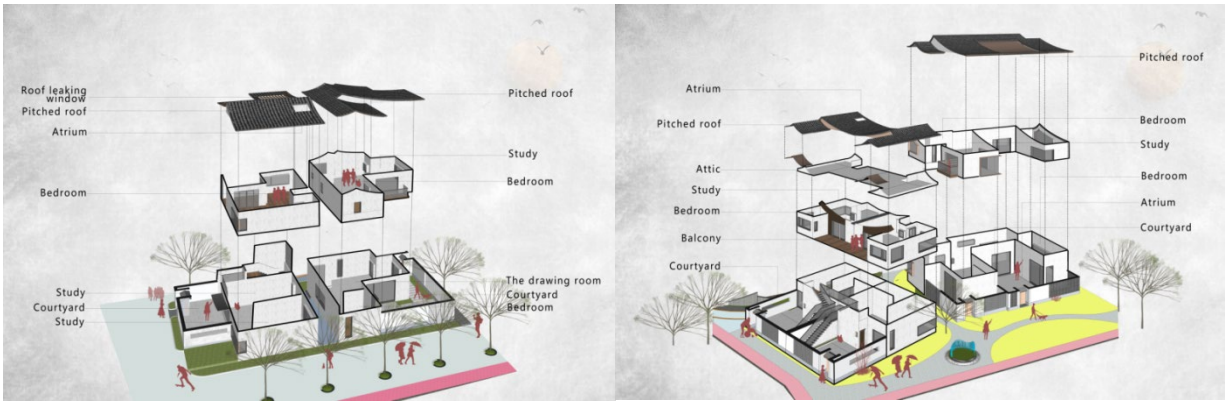

Figure 12 Residential courtyard space analysis

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In the updated design, the ventilation system and lighting conditions are improved to improve indoor air quality and reduce the breeding of moisture and mold (Figure 14). While fully considering the modern functional needs, the cultural connotation of traditional space is also retained. The sloping roof design makes the residential courtyard more diverse and layered. Even in modern form, the courtyard still serves as the social center of the family, promoting family interaction and contact with nature, which also forms the core values of traditional Chinese residential architecture.

2.3.2 Refinement and reconstruction of the form of residential space composition

Oscar Newman（Newman, 1972）first systematically introduced the concept of 'defensive space,' comparing physical designs in public housing projects in New York, such as the Pruitt-Igoe in the Bronx, with nearby low-income neighborhoods, to examine how physical design impacts crime rates. In the study of 'defensive space,' the focus is on how clearly defining public and private spaces can enhance a sense of belonging and security. Therefore, this study is also based on the established principles of how people experience and use residential space. In the reconstruction process, traditional spatial forms are integrated with contemporary functional requirements to achieve a “reorganization and reconstruction” of traditional residential spaces, thereby forming new living environments. Firstly, based on the common needs of family members and the spatial characteristics of courtyards, a sequential spatial hierarchy from “public – semi-public – private” is established (Figure 13). While the functional role of the traditional central hall (tangwu) is redefined, its cultural symbolism is preserved. For example, the common area of the first floor becomes the living room and guest reception area of the home, still retaining a flexible multi-functional space. Take the "C" type house as an example. The outer yard (blue) is the public interface with the street, the main building (yellow) contains the living area, which is a semi-public area for family and guests to live in, while the inner room or second floor (orange) is the private space of family members.

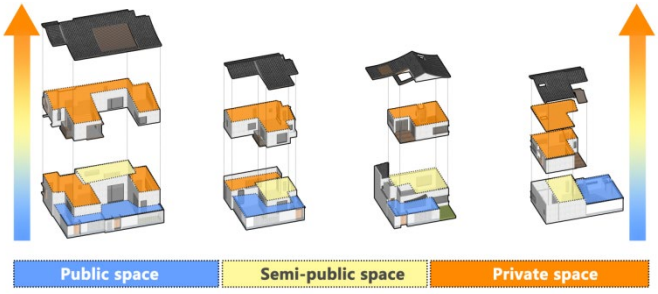

Figure 13 Residential space sequence

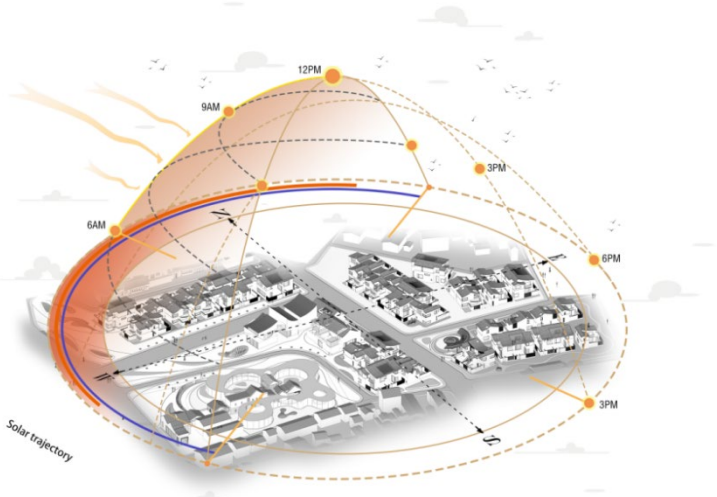

Figure 14 Residential space sequence

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2.3.3 Design and transformation of residential space design layout features

Traditional residential space is not limited to the house itself but constitutes an integrated environment that includes roads, greenery, landscaping elements, and courtyards. The book Charm of Ancient Dwellings: A Cultural Overview of Traditional Suzhou Residences provides a detailed discussion of Suzhou's traditional residential background, construction artistry, interior furnishings, and historical evolution. It reflects not only residential customs and interior-exterior spatial organization but also emphasizes the cultural atmosphere and the design of external spaces and environments (Shen, 2013). The overall courtyard layout is achieved through the combination of four basic residential units, forming a replicable and scalable residential system that demonstrates strong integration with the natural environment and spatial adaptability. The activity space layout of dwellings responds to the mountainous terrain and water systems of Dongshan, adopting a flowing spatial configuration to reinterpret regional cultural symbols of traditional housing and extend them into new residential village layout (Figure 15).

Figure 15 Plan of residential village

In addition, through the adjustment of spatial layout in the residential village space, the use of moving lines was optimized to make the living space more in line with the living habits of modern people (Figure 16). In the external space, the public space is redesigned, and by setting up tourist gathering and distribution areas, shared study rooms, public corridors and leisure Spaces, it not only meets tourists' demand for sightseeing, but also improves community cohesion and residents' sense of social belonging. The four perspectives of environment, culture, psychology and behavior are combined to form a multi-dimensional design idea.

Figure 16 Spatial moving line analysis

Citation
Zhou, H., Inkuer, A., & Mayusoh, C. (2025). Study on Spatial Reconstruction Strategy of Dongshan Traditional Residential Buildings from the Perspective of Adaptive Design. International Journal of Sociologies and Anthropologies Science Reviews, 5 (5), 1017-1040; DOI: https://doi.org/10.60027/ijsasr.2025.8116

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The overall layout adopts a “clustered” planning model, wherein the four basic housing units are combined to form diversified residential groupings. This ensures the continued development of traditional village diversity. In the external spatial arrangement, a balance is sought between openness and privacy (Figure 17). In response to the desire of 75.5 percent of respondents to combine development with cultural tourism, the new layout establishes a clear core axis and a central node area for tourist services and cultural displays. Semi-open courtyards and communal activity spaces are introduced to strengthen interaction and communication among residents. A multifunctional public square is positioned at the village center, preserving the role of the traditional market while serving as a space for daily rest and social interaction. Additionally, landscape elements are optimized to improve overall environmental quality. Ecological corridor pathways are integrated into the existing spatial framework to connect key squares and preserved residential sites. These not only offer spaces for recreation and leisure but also enhance the cultural appeal of the residential environment through a well-organized landscape system. The book "The Charm of the Ancient House" puts forward that the external environment is an important part of residential life. This study also demonstrates the overall design strategy through cultural display wall, ecological corridor and other design strategies, which can be successfully implemented from individual houses to the whole village.

Figure 17 Spatial node analysis

2.4 Combination of residential functional zoning and living needs

2.4.1 Functional zoning design

The spatial layout of this residential village retains both the implicit cultural memory and the historical narrative embedded in traditional dwellings. This adaptive design strategy, grounded in theoretical research on Dongshan dwellings in Suzhou, proposes five functional zones: a professional exhibition area, a tourism hub, a central plaza, a cultural-creative residential display area, and a village reading zone (Figure 18). The residential area (pink) is designed to maintain residents' privacy and normal life, keeping them away from the high-intensity tourism activities at the tourist center (blue) and the central square (red). Additionally, the cultural and creative residential display area (yellow), serving as a management interface between residents and tourists, includes guesthouses or craft workshops. These venues facilitate genuine cultural exchanges without disrupting private residences. The green village reading area provides a quiet space for residents and visitors, while the open space design of the central square can be used for local community activities as well as cultural festivals to attract visitors. The professional exhibition area will focus on the display of traditional Dongshan residential building techniques, and the tourism center will provide a good place for tourists to rest and gather. In the design of the pavilion, the roof and courtyard structure of the traditional Dongshan residential buildings are borrowed,

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and the pavilion is designed as a sloping roof structure, which not only continues the traditional Dongshan residential culture, but also increases the interest.

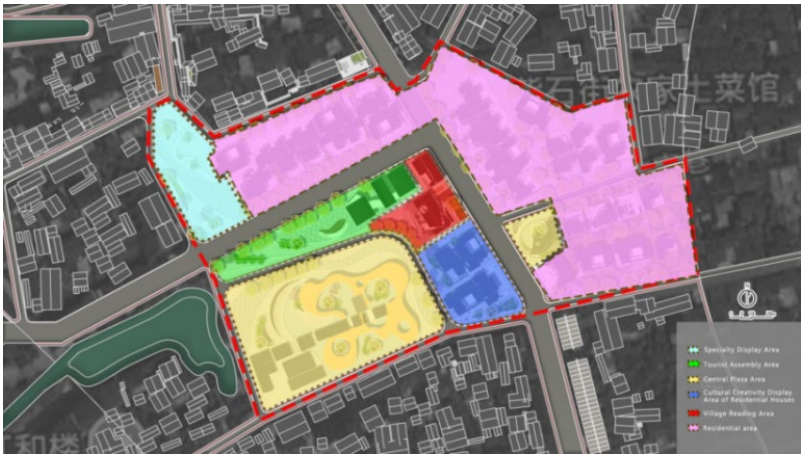

Figure 18 Spatial layout analysis

2.4.2 Integrate regional life needs from multiple angles

This design examines the modern requirements and adaptive design of Dongshan residential buildings from environmental, cultural, psychological, and behavioral aspects.

Environmentally, residential space renewal emphasizes ecological adaptability and sustainable design. It takes full account of local climate, terrain, and the ecological environment. Energy-efficient and eco-friendly building materials are used, while natural light, wind, and water resources are utilized rationally. By increasing greenery and activity areas, it achieves harmonious coexistence between architecture and nature. Moreover, the comfort and health of residents are prioritized during the adaptive renewal of these buildings.

Culturally, the renovation design of residential spaces aims to preserve and inherit traditional cultural symbols, breathing new life into them through adaptive design. The sculpture art, decorative patterns, and architectural forms in Dongshan dwellings carry profound cultural meaning. Additionally, focus is placed on revitalizing and expanding cultural spaces. For instance, public spaces and community facilities, like cultural activity promenades and squares, can be added via partial expansion or renovation, enhancing the public service level of residential areas (Figure 19). A tall mature tree has been planted in the circular rest area of the central square, which naturally becomes the focus and promotes the gathering of the community, satisfying the behavioral and psychological needs of sharing the community center.

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Figure 19 Spatial layout analysis

From the psychological point of view, residential space design should pay attention to the construction of residents' psychological comfort. In the courtyard design of residential houses, a quiet and private living environment is provided, and a warm and quiet living atmosphere is created through reasonable space separation and traditional landscape techniques. It not only retains the typical features of traditional houses, such as eaves, doors and Windows, decoration and other elements, but also enhances residents' sense of belonging to the living space. At the same time, through the design of community public space, neighborhood interaction and cultural exchange are promoted, and psychological identity is further strengthened. Tourist distribution centers are designed to provide one-stop tourism services for local tourists, solve traffic bottlenecks, improve the supply level of tourism services and promote the development of tourism industry. From a behavioral perspective, the spatial usage patterns of traditional dwellings are optimized based on the behavioral habits and lifestyles of modern residents. For example, designs such as expanding the road dimensions between buildings, enhancing street space, arranging benches along roads, and creating small semi-enclosed gathering areas not only focus on physical space renovation but also emphasize improving residents' quality of life, inheriting and innovating culture, and enhancing social interaction. The design of the pedestrian walkway encourages walking and social interaction, while also making it safer for pedestrians and vehicles to pass through the area.

Aiming at the living needs of folk houses in Luxiang Village, we built an adaptive residential space system with the protection of traditional folk house culture as the core and radiation of residents' living culture. Including diversified family structure space, by breaking the strict division of functional areas and adopting a more flexible layout, the living space can be adjusted according to specific needs. For example, the rural reading area can not only meet the living needs of residents, but also meet the display needs of rural culture. This space can be divided and adjusted according to specific activity needs, so as to improve the adaptability of space (Figure 20). By showcasing images of the rooftop terrace, it is evident that this space provides residents with a private outdoor area, allowing them to temporarily escape the hustle and bustle of street life. Moreover, by incorporating traditional tiles and white walls, the modern residential space harmoniously blends with its historical setting, thereby enhancing residents' psychological sense of belonging and identity.

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Figure 20 Village study

2.5 multi-level, multi-functional space design

During the design process, internal and external spaces are organized in layers to create a multi-dimensional spatial experience. Floors, mezzanines, balconies, and terraces add vertical diversity, offering multiple visual and functional layers within each dwelling. These spatial layers enrich the environment and boost inhabitants' engagement with the space. For the façade design, a simple color scheme of white plastered walls, black tiled roofs, and stone landscape walls is adopted. Accents of local brick and timber are incorporated, highlighting the unique construction features of Dongshan residential architecture. Detailed façade treatments incorporate modules of varying solid-void relationships, enriching the articulation of spatial structures (Figure 21). As can be seen from the middle of the main facade, continuous horizontal lines connect multiple residential units, unifying the appearance of the street while allowing for personalized design within each residence.

Figure 21 multi-level residential facade space

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International Journal of Sociologies and Anthropologies Science Reviews
Volume 5 Issue 5: September-October 2025: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index

This design creates a modern and culturally rooted adaptive residential building. The multi-layered interior spaces provide the functional flexibility required for modern life, while the carefully considered facade design ensures that the new village remains in a respectful and meaningful dialogue with its historical and cultural context.

Conclusion & Discussion

Through extensive research and practice, the study has identified four core conclusions regarding spatial reconstruction strategies for traditional Dongshan residences from the perspective of adaptive design, each intricately linked to address the challenges of cultural preservation and modernization.

First, Theoretical Framework for Adaptive Spatial Design of Traditional Residences establishes a theoretical system by exploring the spatial adaptability characteristics of Dongshan's traditional dwellings and their cultural evolution. This theoretical foundation directly informs Methodological System for Adaptive Design in the Contemporary Context, where the proposed modular spatial units are designed based on the identified spatial adaptability patterns. For instance, the hierarchical and symmetrical spatial organization found in traditional "front hall and rear residence" layouts inspires the modular courtyard units, ensuring cultural continuity while meeting contemporary living requirements.

Second, Adaptive Design System of Traditional Craftsmanship and Construction Techniques bridges historical construction wisdom with modern needs. Traditional craftsmanship, serving as a symbol of cultural regeneration, is integrated into the Environmental Adaptation and Spatial Adaptability and Reconstruction methods. The use of local materials and "borrowed scenery" techniques in ancient architectural practices are modernized to enhance the symbiotic relationship between architecture and nature, as seen in the incorporation of vegetation, water features, and glazed glass facades.

Third, Integration of Traditional Aesthetics and Contemporary Needs is realized through reinterpreting traditional spatial logics and decorative arts. The ceremonial function of the central hall, for example, is reimagined to promote family interaction in modern residential design, which aligns with the Cultural Continuity Principle that emphasizes integrating traditional spatial patterns into contemporary updates.

Fourth, these conclusions resonate with established architectural theories. The design strategy, balancing tradition and modernity, exemplifies Critical Regionalism. By leveraging modern techniques like modular design while drawing inspiration from local cultural and environmental contexts, it resists the homogenization of architectural styles. The modular approach also engages with contemporary debates on prefabrication and sustainable construction, offering a scalable and adaptable solution for traditional building renovation.

Recommendation

Based on the achievements and limitations of this study, future research directions should be further expanded in theoretical deepening, methodological optimization, practical innovation, etc. The adaptive design of Dongshan Ming Dynasty dwellings involves not only architecture and cultural heritage protection but also intersects with multiple fields such as social economy, residents' lifestyle, and environmental sustainability. Therefore, future research should adopt a more comprehensive perspective to achieve more forward-looking research goals.

1. Constructing a Dynamic Model for the Adaptive Design of Dongshan Dwellings

This study proposes four core methods: cultural tradition principles, environmental adaptability, spatial adaptability, and modular dwelling unit spatial design methods. However, the applicability of these methods still needs to be verified in a broader range of cases. Future research can further construct a dynamic model for the adaptive design of Dongshan dwellings to systematically analyze building renewal paths under different conditions. For example: analyzing the renovation methods of Dongshan dwellings in different social stages through historical data, summarizing patterns, and predicting possible future development trends; formulating a set of quantitative evaluation indicators such as space utilization rate,

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environmental adaptability, living comfort, and cultural identity to measure the advantages and disadvantages of different adaptive renovation schemes. Such a dynamic model can not only provide theoretical guidance for the renewal of Dongshan dwellings but also be extended to the adaptive research of other traditional Jiangnan dwellings.

2. Expanding Comparative Studies with International Adaptive Design Theories

Future research can attempt to conduct in-depth comparisons between the adaptive design framework of Dongshan dwellings and international theories to explore the similarities and differences between Eastern and Western adaptive design concepts. For instance, Dongshan dwellings emphasize the continuation of cultural fabric, while European adaptive reuse focuses more on the modern functional replacement of spaces. Are there fundamental differences in their value orientations? Through these comparative studies, the theoretical system of adaptive design for Dongshan dwellings can be further enriched, and its academic value in international architectural heritage research can be enhanced.

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