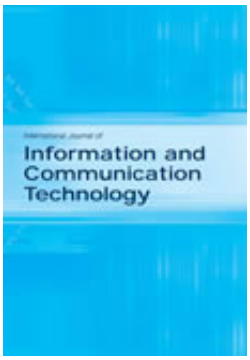

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Spatial revitalisation design of traditional villages in Northwest Henan Province and the influencing factors of regional cultural value

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Spatial revitalisation design of traditional villages in Northwest Henan Province and the influencing factors of regional cultural value

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Abstract: With the ongoing rural revitalisation strategy, the spatial activation of traditional villages and reconstruction of regional cultural values, as carriers integrating aesthetics and public participation, are reshaping the rural cultural landscape. From a regional cultural perspective, this study identifies key factors affecting cultural value in northwest Henan's traditional villages through field research and fuzzy comprehensive evaluation. On this basis, a spatial activation design method is constructed from three levels: point, line, and surface. Results show a strong positive correlation between spatial integrity and cultural continuity. For intangible cultural value, Yangping Village scored only 5.1–6.9, but after optimisation, spatial integration rose to 0.61 and node density to 9.7/km^2. Regarding cultural identity satisfaction, tourists and residents scored 9.51 and 9.12 for natural material cultural strategies. The method thus enhances both spatial value perception and cultural identity, offering a replicable approach for regional village regeneration.

Keywords: traditional villages; space activation design; regional culture; fuzzy comprehensive evaluation method; factors influencing of value.

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1 Introduction

On 3 May 2012, the Ministry of Housing and Urban Rural Development, the Ministry of Culture, the National Cutural Heritage Administration, and the Ministry of Finance jointly issued the Notice on Carrying out the Survey of Traditional Villages, making a clear definition of 'traditional villages (TVs)' for the first time (Li et al., 2022). The notice states that TVs refer to types of villages that have formed early, possess rich traditional resources, and have multiple values such as history, culture, art, society, and economy, and urgently need to be protected (Xue et al., 2025). TVs, as the most intuitive material and spiritual representation of regional culture, have unique historical sedimentation, geographical forms, residential structures, belief systems, and folk expressions. Its spatial layout not only carries the concepts of Feng Shui, ritual systems, and kinship structures, but also reflects the adaptation and transformation of specific groups of people to the natural environment over a long period of time (Tang et al., 2023; Dou et al., 2024). Against this backdrop, scholars both domestically and internationally have proposed numerous theories and methods for optimising TV spaces (Xie et al., 2024; Ge and Xin, 2023; Huang et al., 2024).

For example, Xue et al. analysed the historical geographic information of villages in Hebei Province and summarised the site selection characteristics of TVs at the meso level. They found that their spatial layout was influenced by natural conditions such as mountains, hills, and plains, as well as cultural factors such as ancient passes, military defence, industrial development, and religious architecture (Xue et al., 2025). In addition, Tang et al. constructed a TV cultural tourism spatial quality evaluation system based on scenario theory and drawing on relevant theories of cultural tourism spatial evaluation, with authenticity, drama, and legitimacy as the main subjects. Research showed that authenticity was the core source of competitiveness in the cultural tourism industry. Dramatic design could enhance tourists' cultural immersion and participation. Legitimacy needed to be achieved through institutional reform and operational coordination, thereby promoting the sustainable development of cultural tourism spaces (Tang et al., 2023). Huang et al. explored the spatial advantages of commercial layout in Longchuan Village through street and alley spatial syntax and commercial spatial resistance models. Research showed that Longchuan Village had a small area, strong spatial understanding ability, and commercial space should not be dispersed, but should be concentrated (Huang et al., 2023).

The theory of spatial revitalisation is a widely discussed concept in recent years in fields such as urban and rural planning, architecture, sociology, and human geography. It mainly refers to the use of certain strategies and means to revitalise, revitalise, and

enhance the social value of previously dormant, inefficient, declining, or neglected spaces, thereby promoting the regeneration of spaces (Gao et al., 2023; Li et al., 2024). In the protection of TVs, spatial revitalisation not only focuses on the restoration of physical forms, but also emphasises the use of cultural inheritance methods to promote the revitalisation of traditional spaces in modern contexts (Hua et al., 2024). Based on the theory of spatial activation, Wang et al. conducted an empirical study on 28 traditional ethnic villages in Liandu District, Lishui City, Zhejiang Province using the fuzzy set qualitative comparative analysis method. Research showed that there were four models suitable for the protection and development of this village, namely JSC model, Z&C model, J&W model, and S&C model (Wang and Zhu, 2022). Liu et al. used various methods such as data collection, historical data analysis, and field investigations to analyse the landscape characteristics of TVs, and proposed an 'extraction construction analysis protection' path model. This model not only provided a comprehensive analysis of the cultural landscape of Linpu, but also offered an extensible framework for protecting the ecological and cultural integrity of TVs (Liu et al., 2024).

In summary, the protection and development of TVs are facing many challenges, and exploring rural characteristic resources and constructing a development model that fits their own characteristics is an effective way to solve this problem. However, at present, most studies focus on the construction of macro theories and lack field investigations and operational verifications based on specific villages, making it difficult to form replicable application models. Meanwhile, research on how to systematically and quantitatively identify regional cultural values and directly transform them into spatial activation design strategies remains relatively weak. From the perspective of regional culture, it is not only beneficial to enhance the correlation of the constituent elements of TVs, but also to maintain the continuity of the historical context of TVs. Therefore, the research selects Yangping Village, located in Yangping Town, Lingbao City, northwest Henan Province, as the research object. Firstly, from the perspective of regional culture and spatial activation theory, the researchers initiate their analysis. Starting from the three levels of point, line, and surface and considering different cultural backgrounds, they conduct an in-depth analysis of the material carriers and structural characteristics of TV space. Secondly, through field investigations and literature reviews, the researchers systematically explore and analyse the regional cultural characteristics of Yangping Village. Furthermore, they adopt the fuzzy comprehensive evaluation (FCE) method to systematically identify and analyse the factors that influence its regional cultural value. Finally, the researchers construct a TV space revitalisation design method. Through this new method, the research aims to provide theoretical innovation and practical paradigms for the protection and regeneration of TVs, and promote the sustainable development of cultural spaces in the context of rural revitalisation. The innovation points of the research are mainly reflected in three aspects:

1 Taking regional culture as the entry point, it organically combines material culture with intangible cultural elements, breaking through the limitation of traditional research that only emphasises spatial form or tourism function.

2 Introduce FCE and AHP, and on the basis of the combination of qualitative and quantitative methods, systematically identify the core factors influencing regional cultural values and construct an operational evaluation index system.

3 A multi-level spatial activation design method of 'point-line-surface' was proposed, which transformed the quantitative assessment results into spatial optimisation strategies, forming a complete closed loop from evaluation to design, and enhancing the practicality and replicability of the research results.

2 Methods and materials

2.1 Overview of Yangping Village, Yangping Town, Lingbao City

2.1.1 Geographic location analysis

Yangping Village is located in Yangping Town, Lingbao City, Sanmenxia City, Northwest Henan Province. It is situated in the hilly area of the Loess Plateau at the border of Henan and Shanxi provinces, and is a typical TV on the Loess Plateau built on the mountains and prospered by water. There are four village groups under the jurisdiction of the whole village, with a permanent population of about 400 people. The total area of the village is about 3,000 acres, including about 1,800 acres of arable land and abundant forest and fruit resources. Yangping Village is named after the place name 'Yangping Ridge'. In history, it was one of the important post roads leading to southern Shanxi. There were once post stations in the village, and the ruins of the ancient road still exist today. The village unfolds along the hillside, forming a traditional settlement pattern of 'taking advantage of the slope and using local materials'. The residential buildings are mostly mixed style buildings combining cave dwellings and brick and wood structures. Some traditional residential buildings have a history of more than a hundred years, reflecting the integration of architectural skills and lifestyle in the western mountainous areas of the central plains. The village has a compact spatial form, clear hierarchy, and overall preservation is relatively complete. In 2018, Yangping Village was included in the pilot list for the protection of TVs in Sanmenxia City, becoming one of the key cultural and ecological villages supported by Lingbao City.

2.1.2 Current status of industrial development

The current development status of the primary industry in Yangping Village is shown in Figure 1.

Figure 1 Primary industry of Yangping Village, (a) hillside orchard (b) apple (c) pepper (d) pear (e) honey (f) walnut (see online version for colours)

(a) (b)

As shown in Figure 1, the industry in Yangping Village has long been mainly focused on fruit cultivation. Villagers rely on terraced fields and hillside orchards for agricultural production, and their economic income is centred on economic forest fruits such as apples. They also engage in various understory economic crops such as walnuts, Sichuan peppercorns, and honey, presenting an overall small-scale agricultural economy with households as the unit. Due to the lack of unified organisation and market guidance, products are mainly harvested in a scattered manner and traded in markets, with a single industrial structure and an overall structure that has not yet achieved diversified integration. Through on-site investigation, the existing industrial layout in Yangping Village mainly has the following problems:

1 fragmented agricultural production space, with an average plot size of less than two acres

2 the spatial distribution of tourism facilities is unbalanced, with 80% concentrated in areas with convenient transportation

3 the connection between old and new industrial spaces is not smooth, and there is a lack of functional complementarity.

Figure 1 Primary industry of Yangping Village, (a) hillside orchard (b) apple (c) pepper (d) pear (e) honey (f) walnut (continued) (see online version for colours)

(c)

(d)

(e)

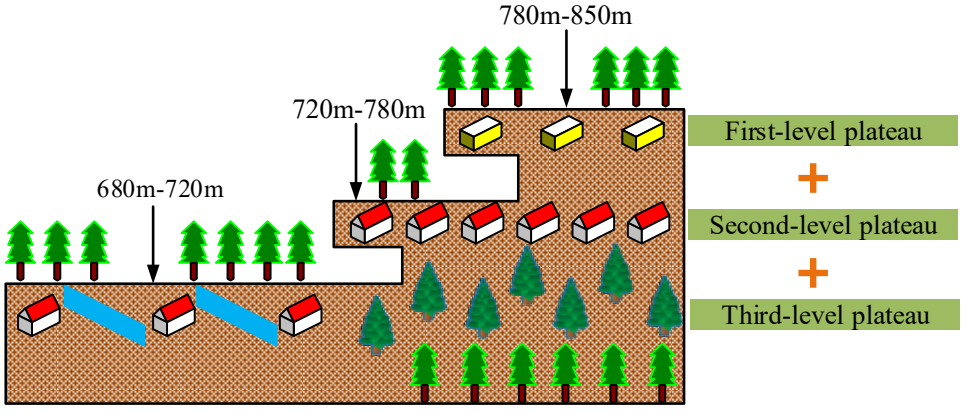
(f)

Source: https://colorhub.Me/

2.1.3 Space issues

The settlement space of Yangping Village presents obvious vertical differentiation characteristics, and the overall shape unfolds in a stepped manner along the terrain height difference. The schematic diagram of its spatial hierarchy is shown in Figure 2.

Figure 2 Schematic diagram of the village space of Yangping Village (see online version for colours)



Source: Authors self-drawn

According to Figure 2, based on the elevation differences, the village space of Yangping Village can be divided into three main levels. First level terrace (altitude 680 m–720 m): Distributed along the river valley, it is the earliest birthplace of the village. There are currently three Qing Dynasty rammed earth dwellings and one ancient post station site, with a building density of about 35% and a relatively loose spatial texture. Secondary terrace (altitude 720 m–780 m): In the sunny slope area, there are a total of 86 cave dwellings and courtyards built in the 1950 s and 1980 s, with a building density of 62%. Third level terrace (altitude 780 m–850 m): A residential area newly built after 2000, mainly consisting of two-story brick and concrete structures with a building density of about 28%. The layout is relatively orderly but lacks distinctive features. To more accurately capture the spatial form characteristics of the village, the research adopts GIS spatial analysis and 3D modelling technology to conduct digital analysis on the terrain, building layout, road network and cultural node distribution of the village, thereby quantifying the integrity and accessibility of the spatial structure and providing a scientific basis for spatial activation design. In GIS analysis, first, by obtaining high-resolution digital elevation model (DEM) and remote sensing image data, the slope, altitude and landform type maps of the village terrain are generated. Subsequently, by using the vector data of village buildings and road network data, the building density, street and alley connectivity, accessibility index and the spatial distribution pattern of cultural nodes were calculated, providing a quantitative basis for the integrity of the village spatial structure. In 3D modelling, based on unmanned aerial vehicle (UAV) aerial images and on-site measurement data, a three-dimensional model of cave dwellings and the entire settlement was constructed, achieving a visual presentation of the village's terrain undulations, building volumes, street and alley networks, and courtyard Spaces, providing an intuitive reference for spatial activation design.

2.2 Comprehensive evaluation method for regional culture

In the exploration of factors influencing the cultural value of TVs, commonly used quantitative analysis methods include expert interviews, literature research, case analysis, and policy analysis (Suardana et al., 2022; Janottama et al., 2024). Based on the actual situation of Yangping Village, the study adopts the literature research method for fundamental analysis. Meanwhile, to ensure the comprehensiveness and reliability of the research conclusions, the study also introduced policy analysis to verify and improve the preliminary results. According to the 'Evaluation and Identification Index System for TVs' standard (Runze et al., 2024), 25 factors that affect the regional cultural value of TVs in Yangping Village were ultimately determined. At the same time, the expert Delphi method was adopted to collect ten experts with rich experience in rural planning, cultural heritage and local development to form a review panel. Among them are three rural planning researchers, three cultural heritage protection experts, two local cultural management personnel and two rural designers with rich practical experience, all of whom have more than five years of working experience in related fields or have published research results in professional journals. The importance of each indicator was scored through two rounds of questionnaire surveys. In each round, experts discuss and revise the scoring results to obtain the initial relative importance matrix of the indicators. Based on this, the analytic hierarchy process (AHP) was further adopted to construct the judgment matrix of the evaluation index system of regional cultural value, and the consistency test of the obtained judgment matrix was carried out (Wang et al., 2023). The weighting process is carried out using the eigenvector method, and its calculation formula is shown in equation (1) (Wu et al., 2023).

$$W_i = \frac{\sum a_{ij} \cdot b_{ij}}{\sum b_{ij}} \tag{1}$$

In formula (1), W_i represents the weight of the i^{th} indicator. a_{ij} indicates the rating of the j^{th} expert on the i^{th} indicator. b_{ij} indicates the relative importance value of the indicator given by the expert. The consistency check calculation formula is shown in equation (2).

$$\begin{cases} CI = \dfrac{\lambda_{max} - k}{n-1} \\ CR = \dfrac{CI}{RI} \end{cases} \tag{2}$$

In formula (2), CI and CR represent the general consistency index and consistency ratio of the judgment matrix, respectively, λ_{max} represents the maximum eigenvalue, k represents the order of the judgment matrix, and RI represents the average random consistency index of the judgment matrix. The weighted indicator system is shown in Table 1.

According to Table 1, in terms of artificial material cultural value, the weight of architectural craftsmanship and structural integrity is relatively high, at 0.085 and 0.075 respectively, indicating that the construction level and structural preservation of traditional architecture are key factors reflecting regional cultural value. At the level of natural material and cultural values, the weights of artistic and aesthetic values are 0.045 and 0.040 respectively, emphasising the importance of the integration of natural

environment and traditional architecture in visual coordination and aesthetic experience for creating regional cultural atmosphere. At the level of intangible cultural values, the weight of functional continuity and preservation of traditional patterns is relatively high, indicating that the continuity of village space use and pattern structure are important basis for cultural inheritance. The weight of subjective indicators such as residents' cultural identity is relatively low, reflecting that current evaluations focus more on the spatial expression and objective inheritance of culture. Overall, the evaluation of regional cultural value should focus on the continuation of traditional construction techniques, spatial structure, and historical functions, in order to enhance the cultural recognition and protection value of TVs.

Table 1 Evaluation index system of regional cultural value

Target level	*Sub-target level*	*Criterion level*	*Factor level*	*Weight*
The regional cultural value of Yangping Village	Cultural value of artificial material forms	The enduring quality of vernacular built heritage	Architectural age	0.038
			Preservation period	0.042
		Integrity of traditional architecture	Integrity of building structure	0.075
			The preservation degree of the decorative style	0.065
			Coherence of architectural groups	0.040
		Proportion and scale of traditional buildings	Building density	0.018
			Building distribution pattern	0.035
			Building land occupation scale	0.020
			Proportion of building land occupation	0.025
		The construction level of traditional buildings	Architectural craftsmanship techniques	0.085
			Characteristics of material usage	0.070
			Stability of building structure	0.060
			Detailed authenticity	0.050
			Enhance the degree of craftsmanship inheritance	0.060
	Natural material form cultural value	Architectural aesthetics and value	Artistic value	0.045
			Aesthetic value	0.040
		Richness of natural elements	Terrain diversity	0.030
			Landscape harmony	0.035
			Environmental ecological integrity	0.040

Table 1 Evaluation index system of regional cultural value (continued)

Target level	*Sub-target level*	*Criterion level*	*Factor level*	*Weight*
The regional cultural value of Yangping Village	Intangible cultural value	The inheritance of regional culture	Functional continuity	0.070
			The degree of preservation of the traditional layout	0.060
			Overall morphological characteristics	0.050
		Historical and cultural typicality	Historical events	0.045
			The historical and cultural background is prominent	0.055
		Cultural values and concepts	Residents' cultural identity	0.035

To comprehensively reflect the actual impact of various evaluation factors on the regional cultural value of Yangping Village, the study further adopted a ten point scale to score various indicators in the evaluation index system of Yangping Village's regional cultural value. Each indicator has clear operational definitions and scoring criteria. For instance, the 'preservation degree of architectural style' is scored based on the integrity of the building's facade decoration, the fidelity of colour, the retention rate of carving techniques, and the harmony with the historical environment. The 'retention degree of traditional layout' refers to historical literature records, the continuity of spatial layout and the continuity of core functions. The continuity of folk activities is measured based on the frequency of annual activities, the number of participants and social influence. A score of 9.0–10 represents excellent, indicating that cultural values are well preserved. 8.0–8.9 points represent excellence and representativeness. A score of 7.0–7.9 indicates good performance, with some aspects preserved; 6.0–6.9 represents average, with defects or updates present. A score below 5.0 indicates poor performance, failure to form a system, or severe damage. The scoring process is conducted in two rounds: in the first round, experts score independently; in the second round, there is a concentrated discussion to correct the disputed scores, in order to reduce subjective deviations and improve consistency. In addition, the study also introduced FCE to construct an evaluation model for comprehensive evaluation of various indicators. The final score D calculation formula is shown in equation (3).

$$D = \sum_{i=1}^{n} W_i K_i \tag{3}$$

In equation (3), K_i represents the scoring score of the i^{th} indicator, and n represents the total number of evaluation factors. To ensure the comparability among the indicators, the study adopts a linear membership function to normalise the scores of each indicator.

2.3 Spatial revitalisation design method based on regional culture

2.3.1 Revitalisation design strategy for artificial material cultural carrying space

To achieve effective protection and systematic reconstruction of TV space, based on the theory of spatial activation, a structurally complete and clearly structured TV spatial system was constructed from three levels: point, line, and surface. Among them, 'point' refers to a single building or place with important cultural value, such as cave dwellings. 'Line' refers to the traditional street network that connects various functional nodes. 'Surface' refers to the overall environmental system composed of various spatial elements. The research takes the index system empowered by AHP and the comprehensive score of FCE as the basis for the quantitative assessment of the cultural value of TVs, and maps different scoring intervals into a 'point-line-surface' spatial design strategy: individual buildings or historical nodes with higher scores are taken as the core objects for protection and revitalisation; the areas with medium scores enhance overall accessibility through the optimisation of road and roadway networks and the connection of nodes. The areas with lower scores are designated as Spaces for renovation or optimisation to enhance their perception of cultural values. During the design process, the points, lines and surfaces are interconnected to optimise the overall spatial structure of the village. Meanwhile, a closed-loop mechanism is designed to ensure dynamic adjustments based on residents' feedback and usage data after implementation, achieving the continuous continuation of cultural value and the scientific implementation of spatial activation. With the continuous improvement of residents' material living standards, the living function of cave dwellings in Yangping Village is no longer able to meet the needs of modern life. Therefore, it is urgent to update and replace the functions of traditional architectural settlements and individual buildings. The design strategy for revitalising the space of cave dwellings is shown in Figure 3.

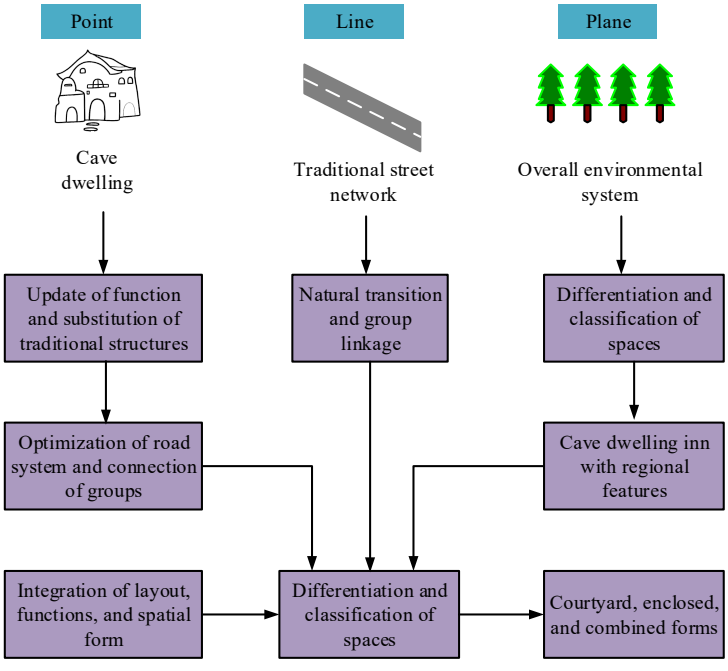
As shown in Figure 3, the study aims to optimise the road system, enrich the connection of regional landscape nodes and functional settings, and improve the convenience of traffic and spatial interest through reasonable road organisation and landscape decoration. Meanwhile, based on the differences in the area of cave dwellings, functional and spatial classifications are carried out to meet the diverse needs of different tourists for accommodation and experience, enhance their immersion and autonomy in cave dwelling life, and thus improve the efficiency of the renovated building. On the basis of respecting the traditional form of cave dwellings, the study also reorganised and redesigned the vertical space of some buildings and kilns, creating a 'cave dwelling homestay' that combines regional characteristics and modern comfort according to local conditions, and shaping a unique rural living experience scene with the charm of Yangping Village.

2.3.2 Natural material cultural carrying space revitalisation design strategy

In recent years, during the construction of beautiful rural areas, Yangping Village has transformed the Wenshui River into a large-scale water feature. Although the scale of the landscape has been increased, there is a clear conflict with the original terrain texture, resulting in a weakened coordination of traditional water system space, and even distortion of landscape style in some areas. To improve this situation, research has

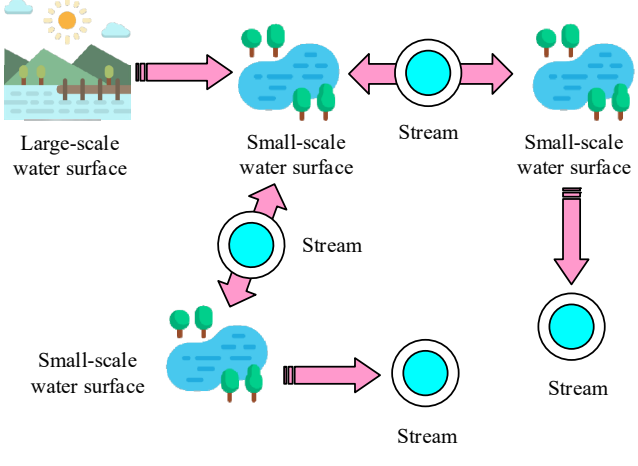
optimised its water system space. The water system landscape design strategy is shown in Figure 4.

Figure 3 Design strategies for revitalising the space of cave dwellings (see online version for colours)



Source: Icons in the picture are sourced from https://freeicons.Io/iconset/free-icons-set

Figure 4 Design strategies for water system landscapes (see online version for colours)



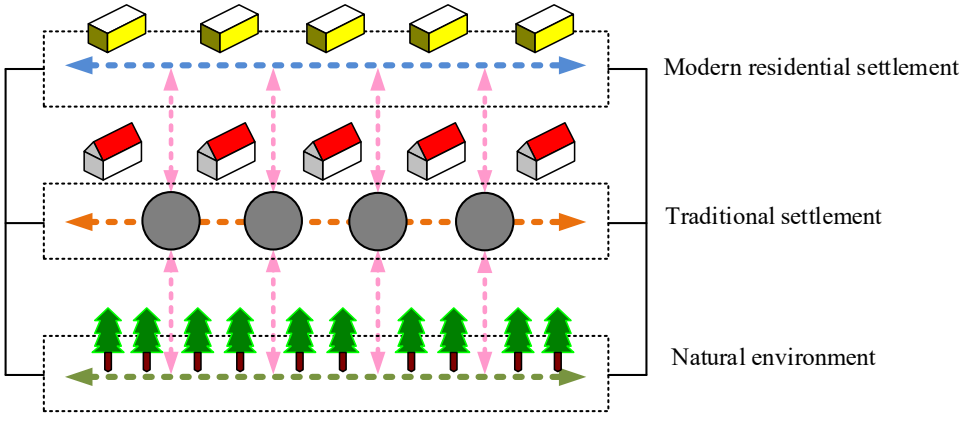
Source: Icons in the picture are sourced from https://freeicons.Io/iconset/free-icons-set

As shown in Figure 4, the study restored the natural direction of the original stream while retaining some open water areas. Through scientific and reasonable water system design, it not only preserved the necessary landscape scale and visual tension, but also reshaped the winding natural form of the stream, making the renovated water system meet modern functional needs and effectively continue the landscape pattern and characteristics of Yangping Village.

2.3.3 Overall space revitalisation strategy

The current spatial layout of Yangping Village presents a state of separation between modern residential areas, traditional cave dwellings, and ecological areas, lacking connection. To construct a spatial revitalisation system centred around traditional cave dwellings, a comprehensive spatial revitalisation strategy of 'connecting corridors and multi-directional linkage; has been proposed. The strategy is shown in Figure 5.

Figure 5 Overall spatial activation strategy (see online version for colours)



Source: Authors self-drawn

As illustrated in Figure 5, the researchers first undertook the construction of a circular transportation corridor. This corridor was designed to organically link the newly-built residential area with the surrounding ecological space, thereby forming an overall spatial framework that encompassed the traditional cave-dwelling area. Secondly, the study team took steps to strengthen the horizontal connections among various functional units within traditional settlements. By doing so, they aimed to enhance the internal accessibility and spatial continuity of these settlements. Meanwhile, the researchers also focused on vertically connecting the interactive channels between traditional settlements, newly-built areas, and ecological spaces. This effort was made to enable the historical architectural complex to assume a core role in spatial integration. Eventually, a composite spatial structure was formed with horizontal 'three zone synergy' and vertical 'coexistence of old and new'.

3 Comprehensive evaluation and analysis of factors influencing regional cultural values

As Yangping Village is a typical small TV, its total permanent resident population is limited. Therefore, the study adopted a mixed method of questionnaire survey and interview for data collection. For the collection of intangible cultural values, the research, based on questionnaires and expert interviews, has added oral history interviews. Through in-depth communication with villagers and elders, qualitative information on folk activities, the inheritance of traditional craftsmanship, historical events, etc. is collected to supplement cultural details that are difficult to cover by questionnaires, providing more abundant data support for the FCE model. In the questionnaire survey stage, a stratified random sampling method was adopted. The target group was tourists and permanent residents aged 18 to 60 in Yangping Village. A total of 100 questionnaires were distributed. After eliminating invalid questionnaires, 93 valid questionnaires were obtained. Although the sample size is relatively small, considering the base population of the village, the data collected by the research institute has covered the main age groups and occupational groups, and can to a certain extent reflect the core cultural characteristics of the village. Therefore, the results of the questionnaire analysis can serve as a preliminary reference for the assessment of the regional cultural value of villages. The statistical description of sample features is shown in Table 2.

Table 2 Investigation sample characteristics and statistical description

Sample characteristics		*Percentage/%*	*p*
Gender	Male	52.7	0.372
	Female	47.3	
Age	18–30	28.1	0.041
	31–45	46.2	
	46–60	25.7	
Educational attainment	Junior high school and below	21.5	0.017
	High school/technical secondary school	35.5	
	Junior college and undergraduate	37.6	
	Postgraduate degree or above	5.4	
Occupation	Farmer	34.4	0.029
	Office worker	41.9	
	Freelance career	23.7	

According to Table 2, the proportion of males in the sample was slightly higher than that of females, at 52.7% and 47.3%, respectively. Among the age categories, individuals aged 18–30 constituted 28.1%, those aged 31–45 made up 46.2%, and those aged 46–60 accounted for 25.7%. These data showed that the samples had good representativeness and could objectively reflect the cultural characteristics of the study area. To further ensure data quality, the study also analysed the reliability and validity of randomly selected questionnaires. The analysis results are shown in Table 3.

According to Table 3, the questionnaire collected by the research has high reliability and validity. Firstly, based on the weight allocation of indicators in Table 1, the FCE membership matrix and corresponding scores of the element layer are calculated using equation (3). Subsequently, following the same method, the membership matrices of the criterion layer and the target layer were sequentially solved, ultimately achieving a quantitative evaluation of regional cultural value. The comprehensive evaluation results of factors influencing regional cultural values are shown in Table 4.

Table 3 Reliability and validity analysis

Serial number	*Number of projects*	*Reliability test*	*Factor variance*
1	5	0.782	0.893
2	10	0.811	0.886
3	15	0.847	0.906
4	20	0.847	0.905
5	25	0.847	0.895
6	30	0.902	0.901
7	35	0.917	0.902

Table 4 Comprehensive evaluation results of influencing factors of regional cultural value

Target level	*Sub-target level*	*Criterion level*	*Comprehensive score*	*Factor level*	*Comprehensive score*
The regional cultural value of Yangping Village	Cultural value of artificial material forms	The enduring quality of vernacular built heritage	7.8	Architectural age	8.0
				Preservation period	7.6
		Integrity of traditional architecture	5.9	Integrity of building structure	6.3
				The preservation degree of the decorative style	5.9
				Coherence of architectural groups	5.7
		Proportion and scale of traditional buildings	6.5	Building density	6.5
				Building distribution pattern	6.0
				Building land occupation scale	6.8
				Proportion of building land occupation	6.6

Table 4 Comprehensive evaluation results of influencing factors of regional cultural value (continued)

Target level	*Sub-target level*	*Criterion level*	*Comprehensive score*	*Factor level*	*Comprehensive score*
The regional cultural value of Yangping Village	Cultural value of artificial material forms	The construction level of traditional buildings	7.1	Architectural craftsmanship techniques	7.3
				Characteristics of material usage	6.7
				Stability of building structure	7.0
				Detailed authenticity	6.4
	Cultural value of artificial material forms	The construction level of traditional buildings	7.1	Enhance the degree of craftsmanship inheritance	6.0
	Natural material form cultural value	Architectural aesthetics and value	7.5	Artistic value	7.7
				Aesthetic value	7.1
		Richness of natural elements	6.7	Terrain diversity	6.9
				Landscape harmony	6.4
				Environmental ecological integrity	7.2
	Intangible cultural value	The inheritance of regional culture	5.7	Functional continuity	6.5
				The degree of preservation of the traditional layout	6.2
				Overall morphological characteristics	5.9
		Historical and cultural typicality	5.4	Historical events	5.1
				The historical and cultural background is prominent	5.3
		Cultural values and concepts	6.7	Residents' cultural identity	6.9

According to Table 4, the ranking of factors affecting the regional cultural value of Yangping Village was as follows: 'architectural age > preservation period > architectural techniques > artistic value > architectural structural stability > environmental and ecological integrity > aesthetic value > architectural density > architectural land occupation scale > architectural land occupation ratio > functional continuity > resident cultural identity > architectural structural integrity > terrain diversity > detail authenticity > decorative style preservation > architectural distribution pattern > architectural group coherence > architectural craftsmanship inheritance > traditional pattern preservation degree > overall form characteristics > historical and cultural background prominence > historical events'. Among them, the score for intangible cultural values was relatively low, and there was still significant room for improvement in cultural inheritance and historical cognition. The cultural value indicators of artificial material forms such as the preservation of decorative style and the coherence of architectural groups score between 5.5–6 points, indicating deficiencies in spatial layout and cultural details. Overall, the regional cultural value of Yangping Village had certain deficiencies in terms of artificial material form cultural value, natural material form cultural value, and non-material form cultural value. Further optimisation is needed through spatial activation design to achieve comprehensive enhancement and sustainable inheritance of cultural value. To enhance the representativeness and reliability of the evaluation results, the study, based on the cultural value assessment of Yangping Village, simultaneously collected relevant data of other typical TVs in the Loess Plateau region, including indicators such as the preservation of architectural styles, the richness of folk activities, the completeness of historical document records, and the degree of regional cultural inheritance, and used them as horizontal control objects. The evaluation results of Yangping Village were comprehensively compared and analysed, and the results are shown in Table 5.

Table 5 Horizontal comparative analysis

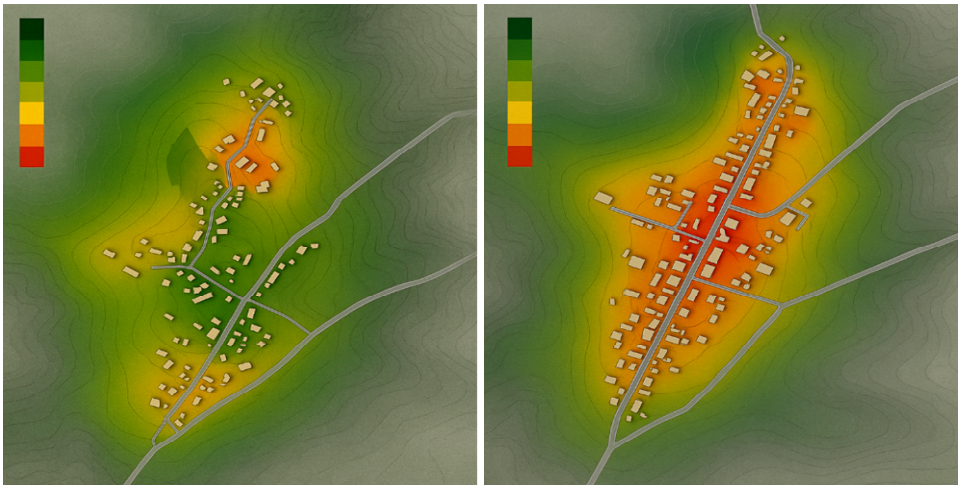
Village name	*Integrity of architectural style*	*The richness of folk activities*	*The value of historical documents*	*Inheritance of regional characteristics*	*Comprehensive score*
Yangping Village	9.2	8.5	8.7	9.0	8.63
Gaojiabu Village	8.7	7.9	8.2	8.4	8.19
Wangjiawa Village	7.8	8.2	7.5	7.9	7.82
Beizhuang Village	9.0	7.5	8.8	8.7	8.48
Nanwan Village	8.2	8.0	7.9	8.0	8.02

As can be seen from Table 5, Yangping Village stands out in terms of the integrity of cultural landscapes, the protection of traditional buildings and the inheritance of regional characteristics. Its overall score is at a relatively high level among the control villages. However, some infrastructure updates or local landscape defects still exist, causing it to be lower than some control villages in certain indicators. Through this horizontal comparison, the research not only clarifies the strengths and weaknesses of Yangping Village, but also helps to conduct a more comprehensive and scientific assessment of the cultural value of TVs in the Loess Plateau region, and provides empirical support for the formulation of subsequent protection and development strategies.

4 Visual comparison of TVs before and after optimisation design

To more intuitively demonstrate the optimisation effect of the proposed spatial activation design method on the space of Yangping Village, a visual comparative analysis was conducted on the spatial form and functional structure of the village before and after the optimisation design. The visualisation results of spatial structure integration are shown in Figure 6.

Figure 6 Integration degree of the spatial structure of Yangping Village before and after the design, (a) before optimisation (b) after optimisation (see online version for colours)



(a) (b)

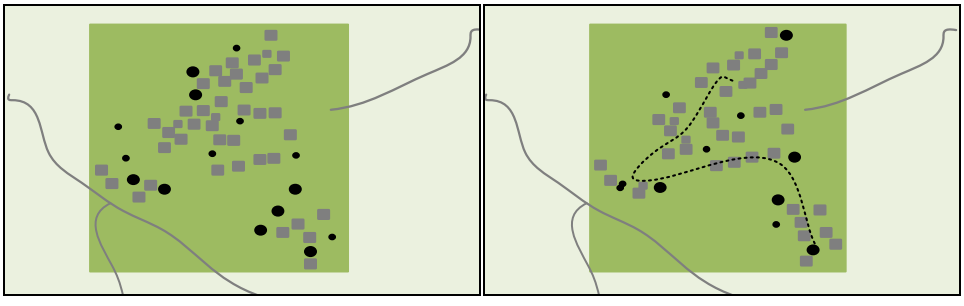
Source: Authors self-drawn

Figures 6(a) and 6(b) respectively show the integration degree of spatial structure in Yangping Village before and after optimisation design. The study adopted a spatial syntactic model and, with the aid of DepthmapX software, quantitatively calculated the street and alley network and node distribution of Yangping Village. Based on the line segment model of the village road network, the global integration degree and local integration degree are calculated, and the scale differences are eliminated through normalisation processing. From Figure 6, before optimisation, the average overall spatial integration degree of Yangping Village was 0.37. The space as a whole presented a pattern of 'scattered settlements + vertical layout'. Due to the undulating terrain and historical development path, the space utilisation rate was relatively low, and the central space of the village lacked effective agglomeration. After optimisation, with the introduction of the circular traffic corridor and the enhancement of street and alley connectivity, the average integration degree has increased to 0.61. Among them, the local integration degree in the core area has increased by approximately 41.2%, indicating that the overall spatial structure is more coherent and the accessibility and interactivity of the main nodes have significantly improved. The convenience of villagers' daily travel has significantly improved, and village activities have also become more concentrated. To ensure the comparability of the conclusions, the study simultaneously calculated the node selection degree and average depth before and after optimisation. The results showed that

the node selection degree increased from 0.24 to 0.46, and the average depth decreased from 6.1 to 3.8, further verifying the scientificity and operability of the spatial structure optimisation. The visualisation results of cultural node density and distribution are shown in Figure 7.

Figures 7(a) and 7(b) show the density and distribution of cultural nodes in Yangping Village before and after optimisation design, respectively. From Figure 7, before optimisation, the cultural nodes existing in Yangping Village (such as the ancient kiln cave group, ancient road ruins, Qing Dynasty residences, etc.) were not systematically integrated and utilised. Many nodes were covered by trees and lacked signage guidance, resulting in insufficient expression of cultural imagery. The average distribution density of nodes was 4.2 per square kilometre, which was extremely uneven. After optimisation, the design took 'cultural corridor' as the main line, connecting nine cultural nodes and setting up cultural interpretation signs, rest stations, and observation decks. Through cultural visualisation, spatial memory expression was strengthened, and the node distribution density was increased to 9.7 per square kilometre, significantly enhancing the readability and accessibility of cultural spaces.

Figure 7 Density and distribution of cultural nodes in Yangping Village before and after the design, (a) before optimisation (b) after optimisation (see online version for colours)



(a) (b)

Source: Authors self-drawn

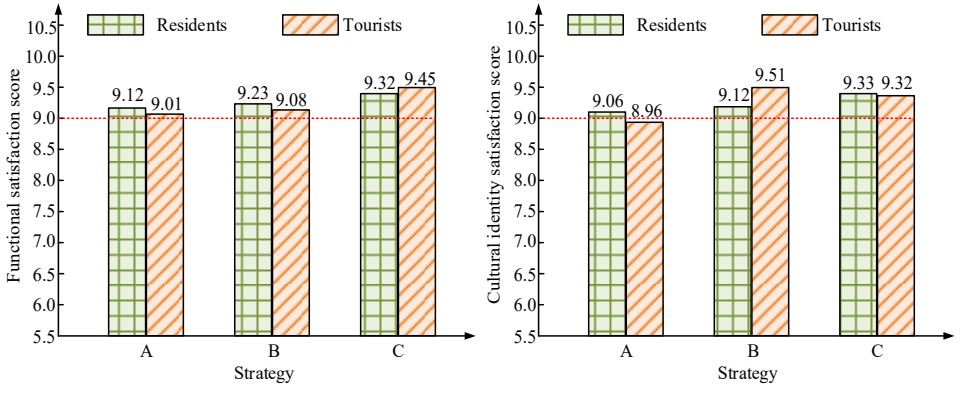
5 Satisfaction analysis of residents and tourists towards the revitalisation design of TV spaces

Through a questionnaire survey, this study analysed the satisfaction performance of three strategies, namely the revitalisation design strategy for artificial material culture carrying space (A), the revitalisation design strategy for natural material culture carrying space (B), and the overall space revitalisation strategy (C), among residents and tourists. The test results are shown in Figure 8.

Figures 8(a) and 8(b) show the functional satisfaction and cultural identity satisfaction ratings of residents and tourists towards the revitalisation design of TV spaces. According to Figure 8, in terms of functional satisfaction, the average ratings of residents and tourists for the overall spatial revitalisation strategy were 9.32 and 9.45 points, respectively, indicating that the overall spatial revitalisation strategy gained high recognition in terms of functional completeness and ease of use. In regard to cultural

identity satisfaction, the tourist group had the highest rating of 9.51 for the natural material cultural carrying strategy, indicating that tourists preferred design methods that integrated with the natural environment and regional culture. The difference in ratings between the artificial material culture carrying strategy and the natural material culture carrying strategy among residents in terms of cultural identity was relatively small, with scores of 9.06 and 9.12 respectively, and the overall spatial revitalisation strategy score was 9.33. To examine whether the difference in satisfaction between the two groups was statistically significant, the study further adopted the independent sample t-test for analysis. The results showed that the difference in scores between the two groups reached a significant level at the 95% confidence interval ($t = 2.17$, $p = 0.032 < 0.05$), indicating that tourists' satisfaction with the natural material cultural carrying strategy was significantly higher than that of residents. Meanwhile, for the scores of the artificial material cultural carrying strategy and the intangible cultural inheritance strategy, the difference between residents and tourists did not reach a significant level ($p > 0.05$), indicating that the two groups have relatively consistent cognition in terms of overall cultural identity. From this, all three types of strategies had a certain degree of agreement. Among them, the overall spatial revitalisation strategy showed a relatively balanced performance in both functional and cultural dimensions, with high comprehensive satisfaction, verifying its promotional value in the revitalisation of TV spaces.

Figure 8 Satisfaction test, (a) functional satisfaction score (b) cultural identity satisfaction score (see online version for colours)



Source: Authors self-drawn

6 Conclusions

The study took Yangping Village in Yangping Town, Lingbao City, northwest Henan Province as a typical representative, and from the perspective of spatial activation theory and regional culture, clarified the key factors that affected the regional cultural value of TVs. Through field investigations, AHP, and FCE methods, the study first analysed the traditional spatial pattern of Yangping Village from three dimensions: point, line, and surface. Subsequently, based on fully extracting regional cultural features, a new spatial

activation design method was constructed. The experiment outcomes revealed that the comprehensive score of the longevity of traditional buildings in Yangping Village was relatively high, at 8.0 points. However, the score for intangible cultural values was relatively low, only 5.1–6.9 points, indicating that there was still significant room for improvement in cultural inheritance and historical cognition. The cultural value indicators of artificial material forms such as the preservation of decorative style and the coherence of architectural groups scored between 5.5–6 points, indicating deficiencies in spatial layout and cultural details. After optimising through research methods, the integration degree of spatial structure in Yangping Village increased from 0.37 to 0.61, and the convenience of daily travel for villagers was significantly improved. Village activities were also more concentrated. The density of node distribution increased to 9.7 per square kilometre, significantly enhancing the readability and accessibility of cultural spaces. In addition, in terms of cultural identity satisfaction, tourists and residents rated the natural material cultural carrying strategies as 9.51 and 9.12 points respectively. The research provided a highly operational theoretical model and practical framework for the spatial regeneration and cultural inheritance of similar villages in the Central Plains region, which had good promotional value. However, the research was limited to individual case analysis and fails to cover regional diversity. In the future, a more universal evaluation mechanism can be constructed by introducing diverse village samples and dynamic monitoring techniques.

Declarations

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The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

The authors have declared that no competing interests exist.

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