# Comparative Spatial Vitality Evaluation Based Sustainable Urban Form

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Sustainable urban forms (SUF) guide spatial creation, significantly revitalise the development of traditional settlements, and are essential theoretical support for urban design. At the same time, the emergence of quantitative spatial analysis technology further promotes the visualised evaluation of the performance of spatial vitality in urban design. The high vitality of an urban settlement could be achieved by combining SUF-based design guidelines and UFI-based evaluation systems. The spatial vitality evaluation system based on the SUF could assist and optimise decision-making in design and act as a paradigm for urban design or urban regeneration in traditional towns.

sustainable urban form | spatial vitality | Space Syntax | urban design | traditional settlement space

## 1. Introduction

Traditional settlements could extend the radiation scope of public services for rural areas, create industrial nodes, and improve township integration [1]. However, due to extensive and intensive urban construction, traditional settlements have faced severe impacts, leading to the destruction of the traditional landscape, insufficient investment and management, and longer-term residents leaving [2][3][4][5]. In response to these challenges, current traditional settlement policies and planning directions are increasingly related to sustainable development [6][7]. For example, scholars have explored traditional settlement environmental creation and intervention combined with bioclimate characteristics [8], protecting and upgrading traditional settlements by improving energy efficiency and reducing energy consumption [9].

However, the merging process of traditional settlement intervention strategies and sustainable development may encounter difficulties, requiring a balance between tangible and intangible values [10]. In this context, SUF theory guides spatial activation and sustainable development, and is an essential theoretical support for urban design in traditional settlements [11].

## 2. The Connotation of Sustainable Urban Form (SUF)

The connotation of a SUF contains broader contents [12][13], which can not only serve as operational guides for shaping spatial forms, but also guide the creation of high-quality urban dynamic space and the reactivation of stock

space [14]. Current research on SUFs mainly includes high density, densification, land use, ecological environment, and other aspects [15][16]. Milder believes compactness is the essential factor for sustainable urban forms [17]. Holden believes sustainable urban development points to dispersed concentrations, relatively small settlements with highly dense populations and short distances between houses and public services [18]. Most relevant research topics focus on urban renewal and transformation, aiming to guide the construction of environmentally friendly spatial forms through SUF theory [19][20][21][22].

In terms of guiding the content of the SUF, compactness, high density, and mixed land use are significant factors that influence spatial vitality in urban design. These metrics are all used to respond to urban problems via rapid urbanisation, and relevant empirical research is also relatively comprehensive. It involves multiple disciplines and has formed a relatively complete qualitative and quantitative evaluation model, including concepts [23]. Scholars believe that the current theoretical exploration of sustainable urban morphology is faced with issues such as effectiveness, social acceptance and practical operability. Scholars have conducted research on sustainable urban form models [24][25][26] and practical applications; just as some scholars proposed a new network structure of a compact and multi-centre mode to guide urban development, others suggested building a new framework for a compact eco-city system by creating a six-law coordination system to make up for the current urban defects, and some scholars of the SUF theory point of view concluded that the urban morphology of Zhengzhou would be “L”-shaped (or sickle-shaped), and with the change of regional development environment, it would be “petal”-shaped or “T”-shaped in the long term [27][28][29].

In addition to urban space, traditional settlements as mediations of conventional culture and vernacular architecture should also be taken seriously [30]. They are a typical spatial carrier for villagers’ working, living, and entertaining activities. The purpose of traditional settlements is mainly residence. The traditional spatial configuration and architectural elements reflect and carry important local culture and customs, represent local history and culture and are crucial for extending territorial identity. SUF theory provides significant guidance in creating vitality in settlements owing to its spatial synergetic and coordination impact [31]. However, few guiding principles focus on traditional settlements based on the SUF or solve issues such as that of “one side of thousand towns”.

## 3. Spatial Vitality Creation and Evaluation

Traditional settlement research focuses on enhancing spatial vitality by forming a high-quality built environment and promoting sustainable development. The guidelines for creating vibrant spaces in settlements include the accessibility of streets [32], architectural forms [33], the functional mixing degree [34][35], and green ecological design in the physical space aspect. In addition, the aggregation of multi-element spaces and multi-level activities are very effective and important ways to reflect the cultural vitality of a space [36], establishing a spiritual space centred on natural landscape images [37], and thereby enhancing the vitality of the settlement space [38].

Current researchers have constructed evaluation methods with a specific judgment matrix based on the SUF [39], such as density, diversity, mixed land use, and compactness [13][40]. These metrics respond to the economic and environmental needs of urban settlements for industries during the transformation process. SUF-based settlement

research methods are biased towards qualitative research, which involves quantitatively evaluating indicators in the evaluation system through field surveys based on interviews and questionnaires [41][42]. However, qualitative and quantitative methods such as the analytic hierarchy process (AHP) [43] and Delphi [44] are used to integrate evaluation results. Limited by sample size, there are still problems of being too subjective and inefficient, making it difficult for these methods to adapt to the current demand for high-quality development of traditional settlements. With a new round of technological breakthroughs and the improvement of statistical methods [45][46][47][48][49][50], new possibilities have been provided for quantitatively assessing sustainable urban morphology. Berghauser and Haupt sorted out the current quantitative methods for determining urban morphology from the perspective of density and space in 2009 [51]. Ye extended the research methods with an urban form index (UFI), including “Space syntax, Spacemate and spatial mixing (MXI)”, and selected three cities with different historical backgrounds in the Netherlands for empirical research. Ye found that the UFI-based quantitative spatial analysis results were matched with those of the GPS individual circulation investigation, proving the analysis framework’s validity and reliability [52]. Recent research shows that the UFI has been proven to have a high reference value for the evaluation of spatial vitality creation [53][54] (**Figure 1**).

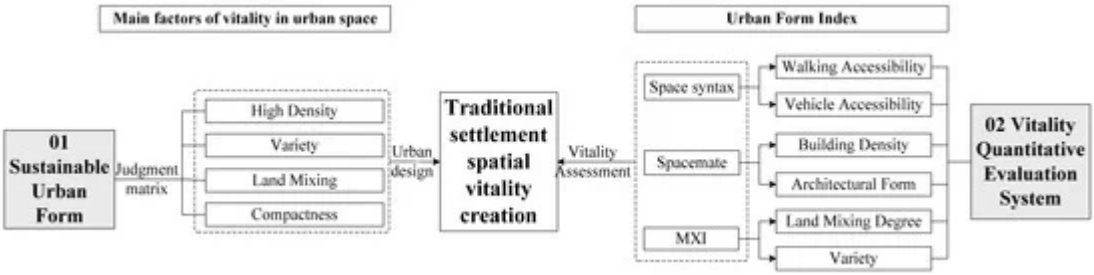


**Figure 1.** Framework for creating and evaluating the vitality of settlement spaces based on SUF.

In general, the current research on creating and evaluating the vitality of space mainly focuses on the urban and regional scale [55], while the methodology focuses on qualitative research [56]. Nevertheless, there are few studies on developing and assessing the vitality of space in small-town settlements with quantitative spatial analysis based on the SUF perspective.

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