

## Valuation of Cultural Ecosystem Services Based on the SolVES Model: A Case Study of Southern Ecological Park in Wuyi County, Zhejiang Province (Postprint)

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### Abstract

Cultural services constitute an important category of ecosystem services and serve as a vital bridge connecting ecosystems and social systems. This study takes the Southern Ecological Park of Wuyi County, Zhejiang Province as the research object, adopts planning application as its orientation, employs the SolVES model as its foundation, supplements it with the expert survey method, and evaluates cultural ecosystem service values using the Value Index (VI). The results demonstrate that: (1) The central and northern regions of the Southern Ecological Park of Wuyi County exhibit relatively high cultural ecosystem service values, with a high-value cultural ecosystem service corridor present in the northeastern area; (2) Niutou Mountain, Yanfu Temple, Liucheng She Ethnic Town-Shili Lotus, and other locations represent hotspots of relatively high cultural ecosystem service values; (3) Surveyed experts regard aesthetics, cultural heritage, health and wellness, and recreation and entertainment values as comparatively important, while assigning relatively lower importance to education, religious, and spiritual values; (4) All six types of cultural ecosystem service values demonstrate a negative correlation with distance from roads and water bodies; forest land exhibits the broadest VI range, while farmland and water areas correspond to relatively higher VI values. The assessment results are applied to the master planning of the Southern Ecological Park of Wuyi County, offering recommendations regarding spatial layout and environmental element improvements. This study concludes that the integration of the SolVES model and expert survey method represents a cultural service valuation approach suitable for planning applications, capable of providing knowledge and technical support for management decision-making.

## Full Text

# Valuation of Cultural Ecosystem Services Based on SolVES: A Case Study of the South Ecological Park in Wuyi County, Zhejiang Province

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## Abstract

Cultural services represent a crucial category of ecosystem services and serve as a fundamental bridge linking ecological and social systems. Driven by planning applications, this research adopted the SolVES model, supplemented by expert investigation, to evaluate cultural ecosystem service values using a Value Index (VI) in the South Ecological Park of Wuyi County, Zhejiang Province. The results showed that: (1) Cultural ecosystem service values were relatively high in the central and northern portions of the South Ecological Park, with a high-value belt present in the northeastern area; (2) Ox-head Mountain, Yanfu Temple, and the Lotus area in Liucheng Town were hotspots with relatively high cultural ecosystem service values; (3) Interviewed experts considered aesthetic, historic, therapeutic, and recreational values more important than cultural and spiritual values; (4) All six types of cultural ecosystem service values showed negative correlations with distance to roads and water bodies. Woodland had the widest VI range, while farmland and water bodies had higher VI values. We applied these results to the general plan of the South Ecological Park in Wuyi County and provided recommendations for spatial arrangement and environmental element improvement. This study demonstrates that combining the SolVES model with expert investigation provides a suitable valuation method for cultural services in planning applications, offering knowledge and technical support for management decision-making.

**Keywords:** ecosystem services; SolVES; valuation; Wuyi County; ecological planning

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## 1. Study Area Overview

Wuyi County is located in central Zhejiang Province and features a subtropical monsoon climate with abundant rainfall. The South Ecological Park of Wuyi County includes seven townships: Liucheng She Ethnic Town, Xilian Township, Daxiankou Township, Daile Township, Shunxi Township, Sankang Township,

and Dakou Township. The terrain is dominated by hills, with forest land as the primary land use type. The forest coverage rate reaches 75.92%, and vegetation types are relatively rich, including evergreen broad-leaved forest, deciduous broad-leaved forest, warm coniferous forest, warm coniferous-broadleaf mixed forest, bamboo forest, and mountain shrubland. In terms of water environment, the main rivers include Xuanping Creek and Ju Creek, both flowing southward into the Oujiang River system. The region retains numerous traditional villages rich in cultural heritage and intangible cultural resources, possessing profound cultural depth and serving as a destination for artistic creation. How to leverage high-quality ecological resources, excavate traditional cultural values, and achieve green sustainable development represents an important issue for this region.

## 2. Research Methods

**2.1 Model Assessment Method: SolVES** The SolVES model consists of three modules: the ecosystem services social value module, the value mapping module, and the value transfer mapping module. The first two require extensive questionnaire surveys for ecosystem services assessment, while the latter can transfer the statistical model to similar areas without survey data to predict ecosystem service values in those regions. The assessment results are expressed as a Value Index (VI), where the maximum value in each value type represents the maximum Value Index for that type. This study primarily applied the value transfer mapping module of the SolVES model, using survey data from the Pike and San Isabel National Forests in Colorado to establish statistical models. The Maxent software embedded in the SolVES model can generate robust models of the relationship between cultural service values and explanatory environmental variables, enabling complete visualization mapping of assessment results. The study area and the source area both share forest park characteristics, with broadly similar environmental factors such as elevation and slope. More importantly, using publicly available data to establish statistical models may yield better accuracy. By inputting relevant geospatial data and selecting the established statistical models, the value transfer mapping module can assess cultural service values in the study area. The prediction performance of the established statistical models in the study area can be diagnosed using the AUC statistic embedded in the SolVES model. AUC values closer to 1 indicate better model performance: 0.5-0.7 indicates low accuracy, 0.7-0.9 indicates moderate accuracy, and above 0.9 indicates high accuracy. The value transfer mapping module significantly reduces the workload of large-scale questionnaire surveys and improves the efficiency of value assessment.

Since the value transfer mapping module may produce errors by potentially ignoring differences between the new study area and the area where the statistical model was generated, this paper employs expert investigation specific to the study area to identify hotspot areas and supplement the assessment results.

**2.2 Expert Investigation Method** Given the subjective nature of cultural service value generation and acquisition, which makes valuation difficult through observed direct or indirect market behaviors, this study adopts a willingness-to-pay survey approach based on expert knowledge. Through questionnaires and expert responses, we determined the relevant values of cultural services. To ensure respondents had sufficient understanding of Wuyi County's ecosystem service quality, the effectiveness of substitutes, and the likelihood of changes, we selected individuals with ecological knowledge backgrounds who were familiar with Wuyi County's basic conditions. The questionnaire core included two parts: allocating 100 RMB investment across six cultural service value types, and identifying locations on maps that reflect these cultural service values. Drawing on Clement et al.'s public value and preference surveys of U.S. National Forests, we selected six cultural service value types strongly relevant to planning processes: aesthetic value, cultural heritage value, recreation value, therapeutic value, and spiritual value. Experts were asked to allocate the 100 RMB investment across these six types based on their understanding of the study area and cultural ecosystem services, and then locate corresponding representative sites on maps for each value type that received allocation, thereby obtaining spatial data for each cultural service value type.

### 3. Data Preparation

Survey data obtained through the above process were vectorized on the ArcGIS platform to create a cultural service value point layer with both value and spatial attributes. Kernel density analysis was performed on this layer, with results standardized to a 10-point scale to identify hotspot areas of cultural service value in the study area, serving as a supplement to SolVES model assessment results.

Geospatial data primarily included relevant environmental data for the study area. Considering that distance effectively reflects spatial relationships between value points and natural resources, and the close relationship between land use type and ecosystem services, we collected land use/land cover (LULC), distance to road (DTR), distance to water (DTW), elevation (ELEV), and slope (SLOPE). These data were stored in a geodatabase, with specific sources and descriptions provided in Table 2.

### 4. Results and Analysis

#### 4.1 SolVES Model Assessment Results

**4.1.1 Relationships Between Value Types and Environmental Elements** The AUC values for all six cultural service value types ranged between 0.7-0.9, indicating good model performance and demonstrating that statistical models of cultural service values and environmental factors (DTR, DTW, LULC) can effectively predict value distributions. Among the six cultural service value types, cultural heritage value showed relatively high VI values at

multiple locations far from water bodies, suggesting that terrestrial ecosystems at some distance from water may also have high cultural heritage value, and that aquatic ecosystems may not be essential environmental elements for high cultural heritage value. Spiritual value showed negative correlation beyond 100m from roads, indicating that spiritual value realization requires convenient transportation but also needs to maintain some distance from roads. The regression fit between cultural service value types and DTR was better than with DTW, which may better predict the impact of road traffic on cultural service values. Woodland had the widest VI range in each cultural service value type, likely related to its largest area and broadest distribution. Farmland and water bodies showed relatively high VI values, indicating that water bodies have high cultural service value.

**4.1.2 Spatial Distribution of Value Types** The VI maps generated by the SOLVES model revealed relatively high cultural service values in the central and northern portions of the study area. This region features a dense network of tributaries, relatively flat terrain, and diverse land use types, which combined to form this high cultural service value area while retaining numerous traditional villages. In the northeastern part of the study area, a strip-shaped area of relatively high cultural service value emerged along the Wuli traffic artery and Ju Creek, though this strip had narrow influence with lower surrounding cultural service values. The spatial distribution patterns of the six cultural service value types were generally consistent.

## 4.2 Expert Survey Results

**4.2.1 Importance Ranking of Value Types** A total of 15 questionnaires were distributed, with 11 returned (73.33% response rate). Supplementary communication with respondents ensured correct understanding of questionnaire content and high completion rates. Based on spatial statistical analysis of expert survey results, the M-VI values for aesthetic, recreation, cultural heritage, therapeutic, and spiritual values were 10, 3, 8, 5, 7, and 2 respectively. This indicates the importance ranking of the six cultural service value types as: aesthetic value > cultural heritage value > therapeutic value > recreation value > spiritual value.

**4.2.2 Cultural Service Value Hotspots** Areas with high aesthetic value concentrated around Ox-head Mountain and Yanfu Temple. High education value areas concentrated around Yanfu Temple. High cultural heritage value areas concentrated around Yanfu Temple and Shanxiabao. High recreation value areas concentrated around Ox-head Mountain and the Lotus area. High therapeutic value areas concentrated around Ox-head Mountain and Liucheng She Ethnic Town. High spiritual value areas concentrated around Ox-head Mountain and Yanfu Temple. Integrating these results reveals that Ox-head Mountain

and the Lotus area are hotspots with high cultural service value, followed by Shanxiabao.

## 5. Discussion

**5.1 Accuracy of Assessment Results** The SolVES model value transfer mapping module essentially uses established statistical models to predict cultural service values in the study area. The AUC values of 0.7-0.9 for statistical models established for each cultural service value type indicate good statistical performance, demonstrating that the relationships between ecosystem cultural service values and some environmental factors obtained in this study are consistent with Sherrouse et al.' s findings. This indirectly suggests that applying these statistical models for value assessment has certain reliability.

The willingness-to-pay survey method infers service values based on respondent answers, with accuracy largely depending on question design rationality and response accuracy. This study' s questionnaire design references Clement et al.' s surveys that have undergone extensive sample practice, ensuring reasonable question design. Drawing on Xie Gaodi et al.' s research using 700 expert surveys to assess ecosystem service values on the Tibetan Plateau, this study limited respondents to those with ecological backgrounds familiar with Wuyi County. Compared to Xie Gaodi' s study, this research area is smaller in scale and lower in complexity, and the expert survey method serves only as an optimization approach based on data model results. The dual requirements of respondent knowledge background and strong feedback validity ensure the representativeness of expert survey results, which align with the 2015 "Finding the Most Beautiful Villages in Wuyi" campaign results initiated by the Wuyi County Committee, indicating certain representativeness.

## 5.2 Advantages of Assessment Method in Planning Applications

Compared with previous cultural service value assessment methods, this study supplements SolVES model value transfer mapping module results with expert investigation, retaining its advantages of wide applicability and convenience while compensating for its limitation of ignoring study area characteristics, thus meeting planning process requirements for scientific rigor and convenience. Presenting assessment results in VI map form intuitively displays the overall spatial distribution of cultural service values and locations of high-value areas, meeting spatial planning needs. This study evaluated six cultural service value types including aesthetic, cultural heritage, recreation, therapeutic, and spiritual values, moving beyond previous research that focused only on recreation value and marginalized other cultural service value types.

## 6. Conclusion

This paper supplemented SolVES model assessment results with expert investigation to evaluate six ecosystem cultural service value types in Wuyi County' s

South Ecological Park. The central and northern portions of the park showed relatively high ecosystem cultural service values, with a high-value belt in the northeast. Liucheng She Ethnic Town, Ox-head Mountain, Yanfu Temple, and the Lotus area were hotspots with high ecosystem cultural service values, followed by Shanxiabao. Interviewed experts considered aesthetic and recreation values more important, while spiritual value was relatively less important. Ecosystem cultural service values showed negative correlations with distance to roads and water bodies. Water bodies had relatively high VI values, while woodland had the widest VI range. Based on these findings, we propose a spatial layout strategy for Wuyi County's South Ecological Park that focuses on improving roads, water bodies, and natural villages to enhance and transform ecosystem cultural service values under the premise of comprehensive protection. This study demonstrates that supplementing SolVES model results with expert investigation provides necessary theoretical and technical support for management decision-making. Future research integrating ecosystem services and planning technologies can provide beneficial references for cultural ecosystem service value assessment and planning applications in similar environmental regions.

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