STUDY ON KEY ASSESSMENT INDICES FOR GATEWAY COMMUNITIES ON THE SUSTAINABLE DEVELOPMENT INDICATORS FOR WUYISAN NATIONAL PARK

Fu-Yao Liu

School of Art and Design, Sanming University

Abstract

Given that China's first batch of national parks was officially established only in 2020, ensuring the rational development and utilization of resources in gateway communities has become an urgent imperative. Based on a case study of Wuyishan and through expert evaluation combined with the fuzzy Delphi method, this study identified universally applicable evaluation indicators and ultimately developed an assessment framework encompassing three key dimensions—Environment, Economy, and Education (comprising 19 specific indicators). Specifically, recreation planning in gateway communities should prioritize three critical directions: visitor behavior management (G^i=9.4), positive contributions to local economic development (G^i=8.6), and ecological network connectivity (G^i=8.5). These results can facilitate a virtuous cycle of conservation and benefit by coordinating environmental and economic development. By integrating educational principles into the process, they translate conservation and development practices into publicly accessible knowledge, thereby providing scientific evidence and practical reference for planning, industrial coordination, and ecological protection in similar gateway communities.

Keyword: National park (NP), Gateway communities, Sustainable development, Fuzzy Delphi method (FDM)

Email：abbyliu0090@gmail.com Tel：86-0598-8399195

STUDY ON KEY ASSESSMENT INDICES FOR GATEWAY COMMUNITIES ON THE SUSTAINABLE DEVELOPMENT INDICATORS FOR WUYISAN NATIONAL PARK

武夷山國家公園門戶社區永續發展關鍵指標評估

劉馥瑤

三明學院藝術與設計學院

摘要

鑒於中國大陸首批國家公園於 2020 年才正式設立，為實現門戶社區資源合理開發利用已成為當前趨勢。本文以武夷山為案例，綜合運用專家評估與模糊德爾菲法，構建了涵蓋環境、經濟、教育三個維度共 19 項指標的評估體系。研究發現，遊憩規劃應重點聚焦遊客行為管控（Gi=9.4）、對地方經濟的積極貢獻（Gi=8.6）及生態網路連通性（Gi=8.5）三項關鍵指標。該結果能通過協同環境與經濟發展，實現保護與收益的良性循環，其在過程中融入教育理念，將保護與發展的實踐轉化為公眾可理解的認知，從而為可為同類型的門戶社區在規劃管理、產業協同與生態保護方面提供科學依據與實踐參照。

關鍵字：國家公園、門戶社區、永續發展、模糊德爾菲法

Email：abbyliu0090@gmail.com Tel：86-0598-8399195

1. Introduction

The gateway communities usually located in a transitional or buffering area and established with the best transportation condition to maximize the services for different functional areas in NP (Steer & Chambers, 1998). The gateway communities adjacent to NPs can provide leisure and entertainment facilities and services while integrating teaching with entertainment. Moreover, they can deepen tourists' understanding of park cultures and natural resources (Steer & Chambers, 1998; Liu, 2016). In the US, for instance, gateway communities can resolve the problems between local residents and NPs and significantly promote local economy (Thomas et al., 2014).

Compared with the core zones of national parks (NPs), gateway communities are subject to fewer land-use restrictions, and gateway community's tourism is mainly developed for economic revitalization and public tourism. Public tourism has imposed many negative effects on local areas and made an urgent situation in terms of resource use. To achieve the sustainability of resources, sustainable tourism has become a popular trend today. Thus, due to the negative impacts brought about by thriving tourism, there is a sense of urgency, so that tourism activities initiated in prospect destinations must meet the tourists' satisfaction while not compromising the sites' ecology resources (Simpson et al., 2008; Chen & Li, 2009; Nyaupane & Poudel, 2011; Mearns, 2012; Wang et al., 2016; Cheng et al., 2017; Ocampo et al., 2018). Only by making efforts in space control, ecological protection, township quality, tourist development, social fairness and benefit balance will we be able to accomplish the sustained development of gateway communities.

In other words, analyzing the tourist functions of gateway communities should be regarded as the preparatory work for the planning of NP entertainment and for the popularization of ecological conservation. Currently, there are only a few studies on the positive role of NP gateway communities in the sustainable tourism, and most of relevant studies focus on the contribution of tourist destinations to local economy. To guarantee the sustainability of gateway communities and NPs, it is necessary to integrate gateway communities with sustainable tourism to reduce the problems in local ecosystem, enhance public understanding of nature and reward local gateway communities. As a green industry, it will urge local residents and tourists to pay more attention to ecosystem in a mutually beneficial way (Irshad, 2010; Peroff, et al., 2017; Liu et al., 2017; UNWTO,

2019) and will become an outpost for NPs to reinforce ecological conservation.

It's true, that tourist development will fuel the economy of NP gateway communities, but inappropriate planning (e.g. frequent activities would affect the ecosystem) would also have indirect negative impacts on environment. To prevent gateway communities from causing irreversible damage due to the lack of the experience in the development and planning of sustainable tourism. At present, most indicator systems for sustainable tourism focus on ecosystem, sustained tourism and the sustainability of national land resources. Many institutions have released various indicators for the development of ecological, green and sustained tourism, and all these indicators are based on natural science methods and specific research achievements. But in the application, the basic investigations to be undertaken are highly complicated, so not all these indicators are representative in different natural and cultural contexts. Nor do they meet the operation demand of NP gateway communities in the development of sustainable tourism. Therefore, it is necessary to redefine indicators.

Through an in-depth examination of the traditional Chinese philosophical principle of "Harmony between Heaven and Humanity", the relationship between landscape ecological design and recreational functionality is conceptualized as one of "unity and coexistence". This framework serves to disseminate a philosophically grounded perspective to the broader public. China formally established its NP system in 2020 (cases from Hong Kong, Macao, and Taiwan are not considered in this analysis), yet public awareness and comprehension of NPs remain underdeveloped. Gateway communities near scenic areas have historically relied on mass tourism and commercial ventures (e.g., the Impression Da Hong Pao Circle in Wuyishan NP) for their livelihood. Striking a balance between conservation and development continues to be a major challenge.

With emphasis on NP community, this paper adopted the Fuzzy Delphi Method (FDM) and the expert questionnaire to define the dimensions and indicators of the evaluation system for gateway communities to promote sustainable tourism with Wuyisan as an example. Besides, the most representative indicators of the dimensions were selected. Despite that there are a large number of indicators for evaluating sustained tourism in the international community, some of them are too complicated and overlap with each other, making it difficult to conduct a fast analysis of problems. Hence, this paper attempts to select representative and simplified key indicators through expert

evaluation and the FDM, so as to provide some proposals for future programs.

2. Research Method

2.1 Design of sustainable tourism indicators

Based on a comprehensive analysis that elucidates the interdependent and co-evolving relationship between gateway communities and the national park system (NPs), this study proposes three key strategies for sustainable development. e.g. The town of Estes park is one of main gateway community in the Rocky Mountain NP for USA, with the development of tourism, significant growth of tourists in the town and of visitors and residents in the gateway communities for both those communities and the parks, but also caused various environmental problems (Department of Community Development, 2013; Avalanche Consulting, 2015; Liu, 2016). To begin to understand why, the essence of that is the unbalance of the relation between human and nature. Thus, sustainable development is most significant in tourism transition of gateway communities in NP.

Sustainable tourism incorporates the principles of ecotourism, that is environmentally responsible travel. It's a sustainable form of tourism in that it promotes low impact, non-consumption and local orientation, giving the maximum economic benefits to the area, while promoting sightseeing, ecological education, and research activities under the larger context of doing no harm to the environment (Fennell, 2001; Simpson et al., 2008; Mazaris et al., 2014). During the tourism process, in combination with the calculation and application of carbon footprint, each tourist is equipped with a low-carbon tourism facility for use (public transit tools, bicycle, or repetitive daily supplies) to promote the consumption methods of energy conservation and emission reduction, and thus, establish a tourism environment with carbon balance (Simpson et al., 2008; Chen & Li, 2009; Huang & Deng, 2011; Horng et al., 2012; Liu et al., 2017; Sustainable Travel Taiwan, 2020). Sustainable tourism is to change the traditional way of tourism, improve people's ecological responsibility, local economic vitality, and experiential richness (Meler & Ham, 2012; Pham & Chen, 2015; Green tourism Association of Taiwan, 2019; Sustainable Travel Taiwan, 2020). Sustainable tourism is utilized to change the negative effects of traditional tourism on environment, strengthen people's ecological responsibility, boost local economy and enrich tourist experience. Can be used to manage the environment, development social-culture in stable and

sustainable, and develop financial of local communities (Ross & Wall, 1999a; 1999b; Das & Chatterjee, 2015; Pham & Chen, 2015). Furthermore, sustainable tourism can help to raise awareness among tourists and gateway communities of the importance of biodiversity to our everyday lives, and sustained yield of resource.

Literature was used to build an indicator framework. Literature, field investigation and interview were taken as the sources of indicators (e.g. IUCN, UNEP, WWF, Green Globe 21, Charter for Sustainable Tourism, UNWTO & CST). After 26 indicators were defined through the explanation of the bibliographies and relevant theories, the FDM was adopted for the indicator selection. After reviewed references and relevant theories, it offered to construct 26 indicators, and returned to screening with FDM indexes (Figure 1) (Holden, 2000; IUCN, 2006; Tsaur et al., 2006; Chae et al., 2012; Schiavetti et al., 2013; Das & Chatterjee, 2015; Yen & Chen, 2016; Liu et al., 2017; Ocampo et al., 2018; Sustainable Travel Taiwan, 2020).

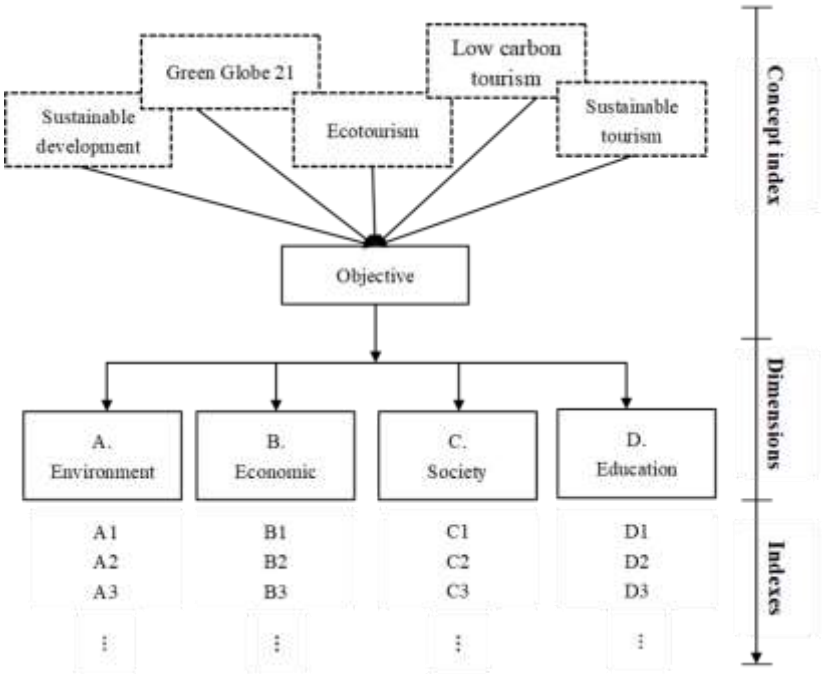


Figure 1 The source of four concept index

2.2 Establishment of Fuzzy Delphi Method (FDM)

Fuzzy Delphi Method (FDM) is a method proposed by Delphi Technique who developed it from the fuzzy set theory. It can be applied to group decision-making to solve

the problem of fuzziness in the degree of consensus among experts and thus increase the efficiency and quality of questionnaire. In this paper, the FDM was utilized to define indicators. Compared with the traditional Delphi method, the following advantages are identified: reduced survey frequency; comprehensive documentation of expert opinions; improved systematicity and alignment with stakeholder requirements of expert knowledge via fuzzy theory application; and improved cost-time efficiency (Chen et al., 2016).

After that, such concepts as "cumulative frequency distribution" and "fuzzy integral" and "triangular fuzzy number" were used to combine expert opinions into fuzzy numbers. Objective evaluation factors were then selected from the statistical results. The FDM-based calculation is as follows (Ishikawa et al., 1993):

(1) Define the triangular fuzzy number (A) for the appropriateness of the initially-selected indicators.

(2) Define the affiliated functions of the maximum and minimum sets ~ μmax (x) and μmin (x).

(3) Make a statistical analysis of each item (i) (importance and emergency), and calculate "Most conservative perception value (C_i)" and "Most optimistic perception value (O_i)" respectively.

(4) Define the triangular fuzzy numbers of "Most conservative perception value" and "Most optimistic perception value".

(5) Check if a consensus has been reached among experts. If the two triangular fuzzy numbers do not overlap or ($C_{Ui} \leq O_{Li}$), it means that there is a consensus section among the expert opinion interval values and that the opinions are in this consensus section.

$$G^i = \frac{C_M^i + O_M^i}{2}$$

If the two triangular fuzzy numbers overlap or ($C_{Ui} > O_{Li}$), it means that there is no consensus section among the expert opinion interval values and that the difference in opinion between the two experts who offer extreme value opinions (the most conservative value in the optimistic perception and the most optimistic value in the conservative perception) and other experts is not great enough to cause a dispute.

$$G^i = \frac{\left(C_U^i \times O_M^i\right) - \left(O_L^i \times C_M^i\right)}{\left(O_M^i - O_L^i\right) + \left(C_U^i - C_M^i\right)}$$

If the two triangular fuzzy number overlap or ($C_{Ui} > O_{Li}$) and the gray zone of the fuzzy relationship ($Z_i = C_{Ui} - O_{Li}$) exceeds the interval of the "geometric average of optimistic perception" and "geometric average of conservative perception" of this evaluation project ($M_i = O_{Mi} - C_{Mi}$), it means that there is no consensus section among the expert opinion interval values. Therefore, the "geometric average of optimistic perception" and "geometric average of conservative perception" of the non-convergent evaluation projects of these opinions are offered as reference information to experts. Then, the procedure is repeated until the convergence of all the evaluation projects and the "consensus importance value (G^i)" is obtained.

As for the testing value (Z^i) of the gray zone, ($Z^i \geqq 0$) indicates the existence of gray zone in this paper. In terms of the difference (M^i) between the optimistic perception value and the conservative perception value, indicator convergence depends on the relationship between (M^i) and (Z^i). If $M^i > Z^i$, it means that expert opinions become increasingly consistent and the indicators have converged; thus, it is unnecessary to conduct the second questionnaire investigation. To facilitate the calculation, make $M^i - Z^i$. If $M^i - Z^i > 0$, it means that the indicators have converged; otherwise, there is no convergence and thus the indicators should be removed. Finally, relevant indicator importance selection numbers are defined according to different studies and research demands. At present, the common thresholds range from 6 to 8 (Dzeng & Wen, 2005).

In terms of the number of experts, it ranges from 10 to 30 in most cases, but it can be reduced to 5 to 10 if highly heterogeneous experts are concerned. The lowest group error is accompanied with the highest reliability (Delbecq et al., 1975; You, 1996; Chung et al., 2017). Through group decision-making groups, this paper collected expert experience and perception as the basis for evaluation. Those from the academic and industrial circles were chosen as the subjects of the questionnaire investigation. The specific requirements on the subjects are as follows: those who have been engaged in ecotourism, forestry, environmental engineering, national land resources and relevant fields will be defined as academic subjects; those who have worked as an interpreter in urban and rural planning, gateway communities building, environmental protection,

ecosystem or relevant fields will be defined as industrial subjects. The sampling of experts in this paper should be evaluated as medium level of homogeneity. Therefore, the average distribution method was adopted to select the 25 experts, with 13 academic experts and 12 industrial experts.

The subjects were divided into "academic expert group (13 people)", consisting of experts of forest science (3 people), education (4 people), environmental engineering (3 people) and eco-tourism (3 people). The industrial expert, they have at least 10 to 20 years of work experience, as an "tour guide (5 people)", "interpreters (5 people)" and "policy adviser (2 people)" for NP.

2.3 Scope and Limitations of the Study

This research focuses on the portal communities surrounding NPs, with Wuyishan NP serving as the primary case (Figure 2). Spatially, the study is confined to these gateway communities and does not encompass the strictly protected core zones or more distant peripheral regions. Temporally, it centers on the period following the establishment of China's NP system, particularly since the formal designation of Wuyishan in 2020. The study examines multiple stakeholders, including local government agencies, village collectives, Indigenous residents, and tourism operators, with a focus on their roles, interactions, and collaborative mechanisms in sustainable development and recreation management.

While this study strives for comprehensiveness and depth, certain limitations should be acknowledged. First, mainstream international sustainability assessment frameworks face challenges in adapting to China's specific governance context, particularly concerning issues such as collective land ownership, the urban–rural dual structure, and variations in community self-governance, which complicate indicator application and data availability. Second, although the Wuyishan case provides valuable insights into community participation, the generalizability of its model to regions with distinct geographical, cultural, and socio-economic conditions requires further validation through broader comparative studies. Third, most existing assessment approaches rely on static cross-sectional data, making it difficult to capture the long-term dynamics of community sustainability or fully account for the lagged and cumulative effects of policy interventions.

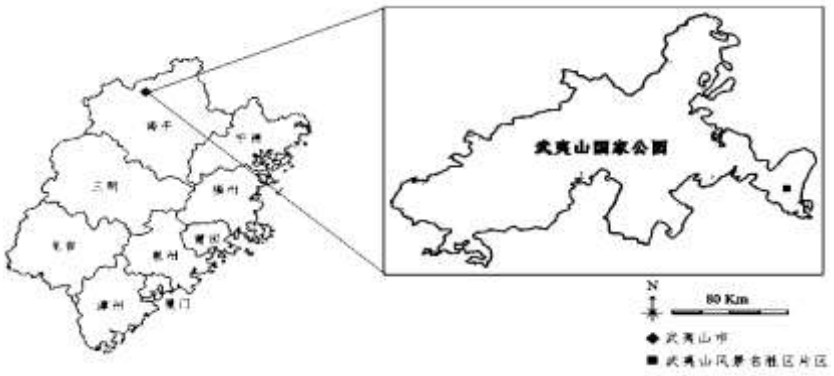


Figure 2. Study Area

3. Results and Discussion

The sustainable development indicators for NP gateway communities cannot be "one-size-fits-all," but the following general methods can enable effective tailoring: 1) Define core challenges: Clearly identify the most pressing ecological and economic issues the community needs to address. 2) Select core dimensions: Choose indicator areas from the three pillars of environment, economy, and education that are most relevant to these identified challenges. 3) Customize specific indicators: Adapt general indicator frameworks into measurable and meaningful local metrics based on the community's culture, resources, and capacities.

According to the results of the expert questionnaire investigation, the difference between geometric averages of the factors listed by the experts, including the minimum (C^i) (most conservative perception value) and the maximum (O^i) (most optimistic perception value), Min value, Max value, optimistic perception value and conservative perception value were M^i, Z^i and G^i respectively.

First, opinion convergence was conducted ($M^i>Z^i$, it means that opinions have converged). As for the expert consensus value (G^i), the importance selection value of the indicators was defined as "6" according to the results of the discussion with the experts. In this paper, the above − mentioned 26 evaluation indicators were modified into 19 ones. Then, these 19 indicators were classified into three dimensions: "Environment", "Economy" and "Education" (Table 1 & Figure 2) according to the similarity in attribute and the framework for the management, labor division, ecotourism and sustained development of NPs. The result is as follows:

(1) Environment: Great emphasis was placed on “Regulation (G^i=9.4)”, “Connection with ecosystem (G^i=8.5)” and “Implementation of ecological conservation (G^i=7.1)”. “The landscape uniqueness (G^i=5.9 < 6)” exerted limited influence on gateway communities in their development of sustainable tourism. Additionally, there was low consensus regarding this factor, and it failed to meet the threshold; consequently, it was excluded. To ensure the proper acquisition, preservation, and utilization of resources, improvements should be made to basic environmental investigations and evaluation-adjustment strategies.

(2) Economy: The first three consensus indicators were “Positive effects on local economic development (G^i=8.6)”, “Definition of the ratio of benefits left for gateway communities” (G^i=7.0) and “Fairness should be considered in terms of economic benefits for current and future generations” (G^i=6.4). It’s unnecessary to make massive capital or facility investment in the development of sustainable tourism; instead, the participation of local residents plays a key role in the ecological and economic development (Chen et al., 2011). That local communities receive low net benefits; that they feel the biased distribution of economic benefits in the community, little control of the local people over tourism and an increase of inflow of tourists (Das & Chatterjee, 2015; Ocampo et al., 2018). Hence, gateway communities and NPs should follow the principle of mutual benefit. Only by doing so will they be able to attain the sustained local development. In terms of gateway communities’ efforts to develop sustainable tourism, priority should be given to local residents, and “Introduction of supporting funds” (G^i=5.4 < 6) was temporarily excluded.

(3) Society: The social dimension was excluded due to its consensus level among experts falling below the threshold (G^i=5.79 < 6). As noted by the experts participating in this study, the social dimension—centered on quality of life—should be integrated into the three core dimensions: "Ecology," "Economy," and "Education." Strengthening these three foundational dimensions would, in turn, enhance the overall environment.

(4) Education: The first three consensus indicators were “Environmental education and training for employees in relevant industries (G^i=6.6)”, “Professionalism of ecosystem interpreters” (G^i=6.5), “Planning and quality of interpretation” (G^i=6.4) and “Environmental education for tourists and the efficacy of interpretation services (G^i=6.4)”. However, “Number of theme activities (G^i=5.9<6)” didn’t have much influence on

educational improvement but was inclined for marketing popularization. Apart from providing entertainment services, gateway communities need to conserve the ecosystem of NPs and publicize the education on the conservation. Through education, gateway communities should make use of environmental education and publicity to develop consensus on environmental protection and enhance tourists' awareness of environmental protection. Thus, transforming gateway communities into a green tourist destination before the entry into a NP, more emphasis should be placed on the supply of educational services is the best way to combine outdoor entertainment with education as well as a symbol of the integration of tourism and environmental education.

Table 1. Results of the FDM questionnaire analysis for indicators

Indicators	**Z^i**	**M^i**	**E**	**G^i**
A1.Maintenance of biological diversity	2	2.1	0.1	6.5
A2.Landscape uniqueness	2	2.2	0.2	5.9
A3.Precautions for environmental sensitivity	0	4	4	7.0
A4.Connection with ecosystem	0	2.5	2.5	8.5
A5.Planning of ecological engineering	2	2.3	0.3	5.7
A6.Environment monitoring mechanism	0	4	4	7.1
A7.Degree of ecological protection	2	2.8	0.8	6.0
A8.Control over tourist behaviors	0	2.9	2.9	9.4
A9.Minimum impact on environment	2	2.4	0.4	6.1
B1.Establishment of financial management mechanism	1	2.7	1.7	6.3
B2.Priority to the introduction of local talents	2	3.0	1.0	6.1
B3. Return for gateway communities	2	2.1	0.1	6.1
B4.Definition of the ratio of benefits left for gateway communities	0	3.9	3.9	7.0
B5.Positive effects on local economic development	0	3.7	3.7	8.6
B6.Introduction of supporting funds	1	3.4	2.4	5.4
B7.Fairness should be considered in terms of economic benefits for	1	2.4	1.4	6.4

Indicators	**Z^i**	**M^i**	**E**	**G^i**
current and future generations				
C1.Contribution to the sustained development of society	2	3.9	1.9	5.7
C2.Establishment of a cooperation mechanism for all parties concerned	2	2.8	0.8	5.6
C3. Life improvement	1	4.4	3.4	5.5
D1.Professionalism of ecosystem interpreters	1	2.2	1.2	6.5
D2.Completeness of software and hardware	1	2.4	1.4	6.3
D3.Environmental education and training for employees in relevant industries	2	2.9	0.9	6.6.
D4.Planning and quality of interpretation	1	2.8	1.8	6.4
D5.Number of theme activities	2	3.2	1.2	5.9
D6.Package itinerary of ecosystem protection	2	2.3	0.3	6.0
D7.Environmental education for tourists and the efficacy of interpretation services	1	2.7	1.7	6.4

Note: Gray part indicates that the indicator failed to reach the degree of convergence or expert consensus and was lower than the threshold of 6.

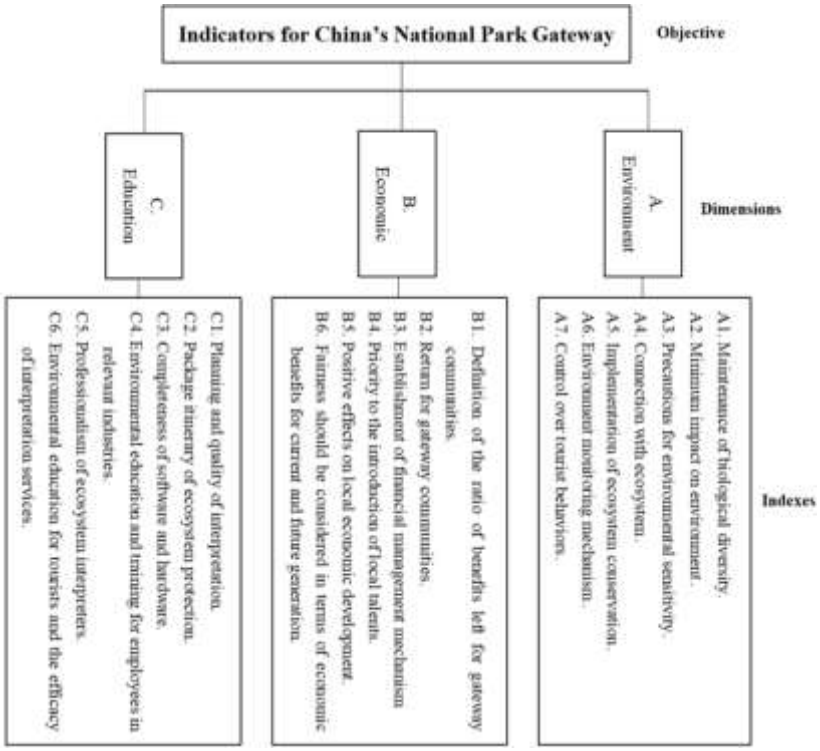


Figure 2. Creating Sustainable tourism Development Indicators for China's National Park Gateway communities

4. Conclusion

This study uses the gateway community of Wuyishan NP as a case study to develop a green tourism assessment framework through the Fuzzy Delphi Method. The framework comprises three dimensions, Environment, Economy, and Education, supported by 19 key indicators. The results demonstrate that the framework is theoretically coherent and practically applicable, providing a viable tool for evaluating the sustainable development of gateway communities.

The Wuyishan case validates the applicability of the "3E" framework. Key environmental indicators, such as visitor behavior regulation and ecological network connectivity, are reflected in the implementation of a visitor reservation system and the construction of ecological corridors, underscoring the role of gateway communities in guiding visitor conduct and mitigating ecological impacts. In the economic dimension, principles like local revenue distribution and intergenerational equity align with mechanisms such as community cooperatives and the realization of ecological product value, highlighting the importance of community agency and long-term benefit sharing.

Within the educational dimension, staff training, professional ecological interpretation, and high-quality experiential design correspond to Wuyishan's emphasis on nature education and in-depth tourism programs, illustrating how education functions as a critical link between conservation and visitor experience.

Theoretically, this study contributes by establishing Education as an independent dimension in gateway community assessment—moving beyond its conventional inclusion under the Social dimension—thus more accurately capturing the integrated "conservation–education–experience" dynamics characteristic of these areas. Practically, the indicator system provides a concise and actionable reference for planning and management in comparable contexts.

5. Research Recommendations

To enhance the framework's foresight and practical utility, transitioning it from a static evaluative tool to a dynamic, adaptive, and intervention-ready governance support system is crucial. This involves refining the framework, deepening the synergy between landscape distinctiveness and education, and establishing future research directions. The specific recommendations are as follows:

(1) Framework refinement and practical suggestions.

It's recommended that the framework be integrated into an adaptive management process, with regular assessments established to track indicator changes dynamically. Comparative studies should also be conducted across gateway communities with diverse ecological and cultural contexts to examine the framework's cross-situational applicability. Furthermore, actionable tools for evaluating educational outcomes should be developed to empirically demonstrate the role of education in linking conservation with visitor experience—particularly through measurable indicators of knowledge, behavior, and place identity.

(2) Deepening the synergy between landscape distinctiveness and education.

Landscape distinctiveness, as a core resource of gateway communities, should be deeply integrated into educational content. It is suggested that a "landscape narrative system" centered on local natural and cultural heritage be developed, along with participatory and experience-based educational programs. Such initiatives can engage both visitors and residents as recognizers, communicators, and stewards of landscape

value, thereby strengthening conservation awareness and local identity.

(3) Future research directions.

In the long term, an integrated "landscape–education–community" observation network could be established to monitor the long-term effects of educational interventions on behavior and ecological conditions. Additionally, the innovative application of digital technologies in landscape education should be explored to further demonstrate the role of gateway communities as models of sustainable development.

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