



National Chi Nan University's Role in Dark-Sky Governance and Regional Revitalization: A Model of Local Engagement and International Vision

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Abstract. National Chi Nan University (NCNU) integrates local engagement with global perspectives, advancing University Social Responsibility (USR) initiatives to support regional development. A key example is NCNU's role in Hehuan Mountain Dark-Sky Park, Taiwan's first internationally certified dark-sky park, promoting sustainable tourism and environmental conservation. Taiwan's tourism industry struggles to balance economic growth with sustainability. In Qingjing, short-stay tourism strains local resources. NCNU collaborated with governments and astronomy associations to develop dark-sky tourism (DST) as a solution to extend visitor stays while preserving ecology. NCNU helped draft the Hehuan Mountain Dark-Sky Park Management Ordinance, aligning lighting regulations with International Dark-Sky Association (IDA) standards. The university fostered cooperation among government agencies, businesses, and astronomy experts to balance conservation with economic benefits. DST integration into hospitality services encouraged eco-friendly tourism, while star-guiding programs built local expertise. Beyond dark-sky governance, NCNU supports regional revitalization in healthcare, Indigenous tourism, and AI-driven smart agriculture. By training professionals and fostering sustainable industries, NCNU strengthens economic resilience, positioning Hehuan Mountain as a global research hub for light pollution studies.

Keywords:

Dark Sky Tourism, Stakeholder Engagement, Hehuan Mountain Dark-Sky Park

1. Introduction

National Chi Nan University (NCNU) is a comprehensive university combining local engagement with global perspectives. Its vision is to become a unique, internationally renowned university distinguished by refinement and sustainability. Since its founding in 1995, NCNU has emphasized local collaboration and international networks, aiming to

cultivate talents with global vision and social responsibility [13].

In recent years, NCNU has received multiple domestic and international USR recognitions, including Repeated awards from CommonWealth Magazine's USR University Citizen Awards; The 2024 Asia-Pacific and Taiwan Sustainability Action Gold Award, Taiwan Sustainable University Gold Award, and Taiwan Corporate Sustainability Report Gold Award; Successful implementation of various Ministry of Education USR programs spanning tourism, environment, healthcare, elderly care, agri-food education, and long term care [14, 15].

In recent years, NCNU has actively engaged in regional revitalization across six Nantou townships (Puli, Guoxing, Yuchi, Mingjian, Ren'ai, Caotun), securing over NT\$500 million in government funding. Among these projects, the Hehuan Mountain Dark-Sky Park stands out internationally: Dark-Sky Park Planning: The project principal investigator—NCNU Vice President and R&D Director—has served as chief planner since 2019, proposing the "Mutually Beneficial International Star Starry Industry Chain" strategy commissioned by the Nantou County Government; Through National Development Council (NDC) proposal submission, the project secured nearly NT\$50 million central funding in 2023 to promote dark-sky tourism, tribal eco-tourism, and international starlight guide training; The Hehuan Mountain Dark-Sky Park has since become Taiwan's first International Dark Sky Association (IDA)-certified park, driving nighttime economic transformation for Qingjing, high-mountain indigenous communities, and regional tourism [13, 16].

Hehuan Mountain Dark-Sky Park (HMDSP) was certified in 2019, becoming the third International Dark-Sky Park in Asia and the first in Taiwan. The park is primarily managed by the Nantou County Government, which assumes the associated rights and responsibilities for dark-sky conservation. With the establishment of HMDSP, dark-sky issues have introduced new business models to the Qingjing area. The element of "stars" has driven the transformation of the local tourism industry, making Dark Sky Tourism (DST) a key component of industrial restructuring. However, as this new model develops, potential contradictions and conflicts of interest may arise among public agencies, the astronomical community, and Qingjing tourism operators. How the local government manages these diverse interests and builds a cross-sector governance model based on consensus has become a significant challenge [17, 18].

2. Theoretical Approach

2.1. Case Study on HMDSP

This study employs a case study to analyze National Chi Nan University's (NCNU) role in assisting the Nantou County Government in supporting local operators in the governance and management of the Hehuan Mountain Dark-Sky Park. As this issue involves complex stakeholder collaboration and governance interactions, the case study method is particularly effective in capturing the negotiation processes and institutional formation across sectors [9, 12].

Faced with the absence of national legislation on light pollution and the demand for local industrial transformation, academic institutions contribute through professional knowledge and intermediary roles in governance, demonstrating practices of resilient governance and cross-sectoral integration [2, 4]. NCNU has long supported the Nantou County Government in promoting local governance, participating in the institutional design, professional training, and policy integration of the Hehuan Mountain Dark-Sky Park, and has become an important knowledge platform for local governance [7, 8, 10].

2.2. Theoretical Foundation of Stakeholder Theory

The governance framework of the Hehuan Mountain Dark-Sky Park comprises stakeholders from both the public and private sectors, including local government bodies, astronomical communities, regional tourism operators, and the educational institution (National Chi Nan University). This intricate cross-sector engagement closely mirrors the analytical paradigm outlined by stakeholder theory. As Freeman (1984) posits, stakeholder theory underscores that an organization's success hinges on the stewardship of relationships with diverse entities that can influence or be influenced by the organization's goals. In dark-sky governance, stakeholders comprise regulatory bodies, commercial entities, community organizations, professional networks, and knowledge contributors [6]. The various interests and often conflicting demands among these stakeholders necessitate negotiation, coordination, and coalition-building to secure sustainable governance results. Donaldson and Preston (1995) further contend that stakeholder theory provides descriptive and practical value by elucidating organizational behavior and steering managerial choices that harmonize economic, social, and ecological interests. For instance, in the Hehuan Mountain scenario, the local government (Nantou County Government) takes on regulatory leadership. At the same time, astronomical communities champion efforts against light pollution, tourism enterprises seek economic advantages, and NCNU offers scientific knowledge, talent development, and cross-sector mediation. The vibrant interaction among these stakeholders embodies the fundamental tenets of adaptive and collaborative governance [1], where cooperative problem-solving and continual dialogue enhance mutual benefits. Thus, the governance of the Dark-Sky Park stands as a testament to a complex stakeholder ecosystem that necessitates ongoing negotiation and adaptable management to reconcile environmental preservation with regional advancement [11].

3. Results and Discussions

The stakeholders involved in the Hehuan Mountain Dark-Sky Park can be broadly categorized into three main groups. Astronomy community includes the Taiwan Dark Sky Protection Alliance, Taipei Astronomical Society, Taichung Astronomical Society, Chiayi Astronomical Society, Tainan Astronomical Society, Pingtung Astronomical Society, Taiwan Parent-Child Stargazing Association, National University Astronomy Club Alliance, Lulin Observatory of the Graduate Institute of Astronomy at National Central University, Institute of Astronomy and Astrophysics at Academia Sinica, and Airy Co., Ltd. Qingjing business operators consists of The Qingjing Sustainable Development Association, Nantou County Qingjing Tourism Association, Huatai Hotel Management & Consulting Co., Ltd., and various local lodging operators in the Qingjing area. The last one is public sector includes the Nantou County Government, Environmental Protection Bureau of Nantou County, Taroko National Park Headquarters, Nantou Branch of the Forestry and Nature Conservation Agency, Qingjing Farm of the Veterans Affairs Council, Tsui-Feng and Mei-Feng Experimental Farms of the College of Bioresources and Agriculture at National Taiwan University, and the Ren'ai Township Office. As shown in Figure 2.

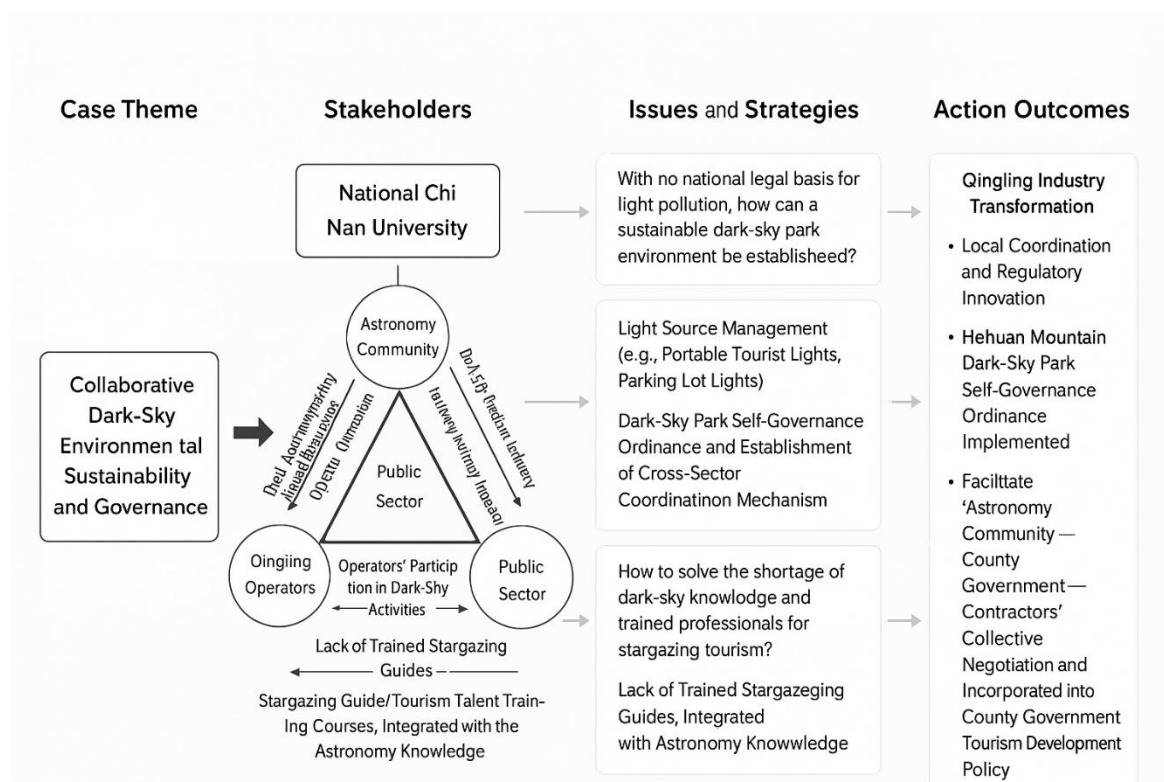


Figure 1. Case study of HMDSP

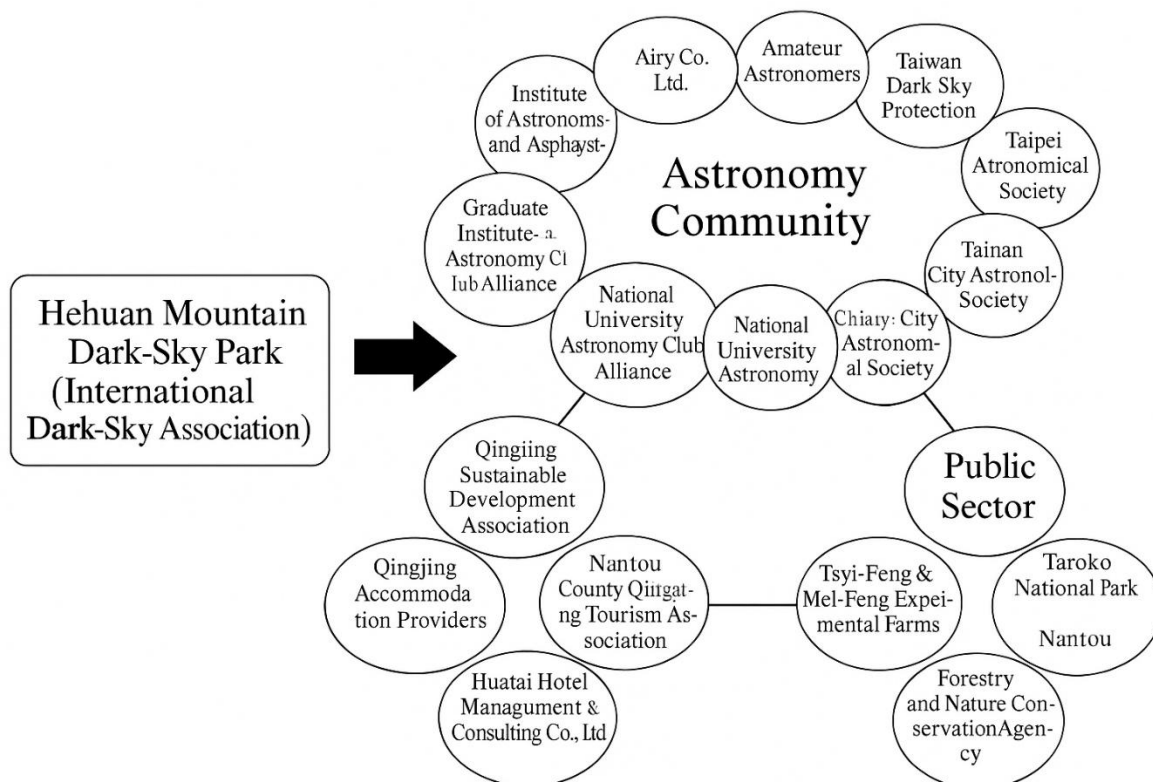


Figure 2. Stakeholders of the Hehuan Mountain Dark-Sky Park

The creation of the Hehuan Mountain Dark-Sky Park highlights Local Dynamics and Emerging Governance Challenges. Insufficient inter-sector communication channels is a challenge, as the dark-sky phenomenon involves multiple sectors, including astronomy,

tourism, education, and government. Each stakeholder group has unique requirements and professional traits, complicating efforts to spark dialogue and cooperation. Without effective inter-sector coordination frameworks, disputes and conflicting interests will likely emerge. Determining how local authorities can address and reconcile these varied demands within a multi-layered, inter-sectoral governance structure is a significant hurdle. Lack of a legal framework for light pollution management such as "dark-sky tourism," "light interference," and "light pollution management" are still largely unrecognized in Taiwan. Current governmental roles and legal systems have rarely addressed these issues. Consequently, nearly no policy instruments are available to monitor the park's lighting or dark-sky tourism initiatives. This prompts a vital question: How can the Nantou County Government fulfill its obligations to reduce light pollution, as required by the International Dark-Sky Association (IDA) and the astronomical community? Dark-Sky tourism development encounters talent shortage and lack of training mechanisms is a challenge, as the establishment of the Dark-Sky Park has opened new avenues for industrial growth in the Qingjing region by promoting the night sky as a central tourist attraction. Nevertheless, with the emergence of dark-sky tourism, the locality grapples with a significant shortage of personnel skilled in astronomy or dark-sky practices, as well as a lack of talent development frameworks. Without qualified guides and interpreters, the quality of tourist experience may be compromised, and over time, such growth could face swift deterioration.

3.1. NCNU's Strategic Solution – A Cross-Sector Integration Mechanism

The dark-sky initiative involves a wide range of stakeholders. How should local governments integrate diverse perspectives and address cross-sector governance challenges while establishing relevant mechanisms?

As a locally-rooted university in Nantou, National Chi Nan University (NCNU) has actively participated in and supported regional development. Even before the formal establishment of the Hehuan Mountain Dark-Sky Park, NCNU was engaged in the process. Since 2021, the Nantou County Government has appointed NCNU as the chief consultant for the "Development Plan of Hehuan Mountain Dark-Sky Park" (hereafter referred to as the "Dark-Sky Master Plan"). Furthermore, through the NSTC-funded "University and Local Government Collaborative Humanities Development and Governance Project" (hereafter referred to as the "Local Co-Governance Project"), NCNU has become a key actor in facilitating regional development and cross-sector governance [19].

3.1.1. Cross-Sector Integration Among Stakeholders: Establishing a Governance Platform

NCNU's team adopted the "governance resilience" concept to co-create a community-centered model with various stakeholders. In 2022, NCNU launched the "Ren'ai Township Regional Revitalization and Hehuan Mountain Dark-Sky Cross-Sector Governance Platform", aimed at bridging gaps between communities and public institutions, integrating multilevel government resources, and facilitating dialogue across communities and issue-based groups.

With NCNU as the intermediary, this platform connects civic groups with local governments to form a governance network for dark-sky issues. It integrates with government resources involves central and local investments in dark-sky infrastructure and services, cross-disciplinary expertise, including astronomy, environmental education, public administration, tourism, and aesthetics, as well as multi-sector consensus building, which is achieved through cooperation among hotels, restaurants, transportation, and marketing sectors, dark-sky principles become part of local cultural identity.

To support governance and negotiation, NCNU organized three types of stakeholder engagement meetings, namely Monthly Coordination Meetings of the Dark-Sky Master Plan (with astronomy communities, Qingjing business owners, and academia), Collaborative Platform Meetings of Ren'ai Township and the Dark-Sky Park (with all stakeholders involved), and Hehuan Mountain Dark-Sky Opinion Leader Forums (involving government, astronomy communities, tourism operators, and universities) [20].

Based on meeting outcomes, the stakeholders' core interests were identified as follows, astronomy communities focused on light pollution control and mitigation strategies, Qingjing business operators emphasized the development of dark-sky tourism and the cultivation of talent, and government agencies sought astronomical expertise and consensus-building mechanisms to jointly develop dark-sky tourism.

Key shared interest is how to establish a sustainable dark-sky environment. Stakeholder relationship include astronomy groups and tourism operators regarding advocacy of dark-sky concept, tourism operators and astronomy groups regarding need for trained dark-sky guide, astronomy groups and Nantou County Government regarding legal institutionalization of light pollution control, government and astronomy groups regarding professional consultation, tourism operators and government regarding support for tourism industry transformation, and government and tourism operators regarding incentivizing participation in dark-sky activities (As illustrated in Figure 2).

3.1.2. Strategies for Overcoming Dark-Sky Environmental Governance Challenges

Assisting local government in establishing the Hehuan Mountain Dark-Sky Park self-governance ordinance due to the absence of a central legal framework for light pollution, local governments lacked the authority and tools to manage portable light sources (e.g., car headlights, flashlights, mobile phone lights) used by visitors. In response to the astronomical community's demands for legal enforcement, NCNU assisted in drafting local regulations. Working with community groups, experts, and Nantou County Government (Tourism Department, Scenic Area Administration, and Legal Affairs Division), a draft ordinance was formulated. The "Hehuan Mountain Dark-Sky Park Management Ordinance" passed its third reading on June 17, 2022, and was officially enacted on March 23, 2023.

Establishing a lighting control coordination mechanism – the dark-sky light reduction advisory group. In this context, in addition to portable lighting, fixed light sources (e.g., streetlights and architectural lighting) pose major challenges. NCNU proposed to the Nantou County Government the establishment of a light-reduction advisory group to advance the concept of "dark skies without compromising safety." With the support of astronomical experts, lighting audits and reduction measures were implemented, offering professional guidance that influenced not only public agencies but also park-wide stakeholders and nearby areas.

3.1.3. NCNU's Role in Establishing a Talent Cultivation Mechanism for Dark-Sky Tourism

As dark-sky issues attract more tourists to Qingjing and Hehuan Mountain, tourism opportunities have expanded. However, most visitors currently explore the night sky independently, due to a lack of trained guides. The Nantou County Government, in organizing its annual Starry Sky Festival, has also faced a shortage of qualified dark-sky interpreters. Recognizing the urgent need for local astronomy expertise, NCNU collaborated with the county government to design a training system for dark-sky tour guides, and has since implemented a series of professional development programs.

暗空公園周邊停車場委外-燈光管制事宜



暗空公園防光害

合歡山停車場 車辨系統低亮度

合歡山3座停車場將收費 星空守護團體：防制光害要兼顧



Figure 3. Regarding installing parking lots within the national park, NCNU assisted the Nantou County Government coordinate with parking facility contractors to regulate lighting controls.

3.2. The Promotion and Impact of the Dark-Sky Economy

Since 2019, Hehuan Mountain Dark Sky Park has established 12 stargazing monitoring sites to conduct long-term assessments of night sky quality. According to NCNU investigations, as of 2024, 10 of these monitoring points have shown statistically significant improvements. This reflects measurable improvements in sky brightness and stellar visibility resulting from the implementation of friendly lighting policies and cooperation from local businesses. In terms of industry participation, the Cingjing area and the surroundings of Hehuan Mountain have actively promoted the “Dark Sky Friendly Businesses” initiative. By 2024, more than 100 businesses had joined the initiative through lighting equipment retrofits and light pollution mitigation efforts, demonstrating growing consensus and willingness within the local tourism sector (See Table 1).

Table 1. Indicators Related to Dark-Sky Development in Qingjing Area

Indicator	Baseline / Starting Point (Year / Location)	Latest / Measured Value (Year / Location)	Improvement Extent or Change
Improvement in the number of starry sky quality monitoring sites	12 observation points initially showed no improvement	10 points showed significant improvement from 2019–2022	Approximately 83% of the observation points showed improvement
Number of certified stargazing-friendly businesses	Few participating businesses when Hehuanshan Dark Sky Park launched	Increase to 100 participating stargazing-friendly shops	Increased to businesses
Frequency of weekly stargazing guided sessions	No regular sessions initially	Weekly guided sessions held twice per week at Qingjing Farm (Thurs & Sun)	Two stable weekly guided events added

To strengthen the engagement of residents and tourism operators, the Cingjing Farm,

in collaboration with the Hehuan Mountain Yuanfeng Visitor Center, organizes the weekly event "Stargazing Night in Cingjing." Held every Thursday and Sunday at the Cingjing Guest House, this event features two guided stargazing sessions (at 19:00 and 20:10) and has become a regular nighttime tourism attraction, enhancing demand for both astronomical experiences and overnight stays. Furthermore, Nantou County hosts the annual "Nantou Starry Sky Festival" from May to October, connecting destinations such as Cingjing, Xitou, Dongpu, and Nantou City. The festival integrates ecological tours and family-oriented activities, effectively enriching the diversity and appeal of nighttime recreational offerings.

On the governance and institutional side, local guesthouses—including notable examples such as Guanxingyuan, Tianxing Mountain Lodge, and Zixin Garden—have replaced over 100 outdoor lighting fixtures with dark-sky-compliant models (typically 500 lumens and 3000K color temperature) and installed shielding to prevent light spill from garden lighting. These actions represent concrete investments in dark-sky conservation by local businesses. Overall, the Cingjing and Hehuan Mountain regions exemplify a collaborative model in which public policy, scientific monitoring, industrial engagement, and community participation converge to build a mutually beneficial dark-sky economic ecosystem.

4. Conclusions and Future Perspectives

Our team adopted the shared problem awareness of "how to establish a sustainable dark-sky environment" as the foundation for dialogue and participatory interaction. Through various forms of engagement, our actions have transformed existing governance mechanisms, promoted the transformation of the tourism industry in the Qingjing area, and introduced new governance structures. These efforts have revitalized the local tourism landscape, enhanced stakeholder engagement, empowered local participation, and helped create a new destination brand.

The team facilitated consensus-building through cross-sector governance meetings, leading to innovative coordination mechanisms and policy tools. These addressed the lack of a central legal framework for light pollution control, leading to collaborative solutions for managing both portable light sources used by visitors and fixed public lighting. New training and certification systems were developed in response to the dark-sky tourism talent shortage.

The key outcomes of this case study can be summarized as three major results, that are the "Hehuan Mountain Dark-Sky Park Management Ordinance" was officially enacted on March 23, 2023 (Document No. 府行法字第1120066951號), establishing a legal basis for the park's management, a tripartite decision-making mechanism was established among astronomy communities, the county government and contractors to regulate lighting within and near the park. New lighting installations must now consult dark-sky experts and comply with dark-sky lighting standards, and starlight interpretation talent development has been incorporated into Nantou County's tourism policy. The county government committed annual funding to support the program, and NCNU assisted in drafting the "Starlight Guide Certification Guidelines," which include bronze, silver, and gold levels for future capacity-building initiatives. A schematic representation of this issue and solution framework is shown in Figure 1.

Constructing a cross-sector governance network involving multiple stakeholders requires the presence of shared interests to mobilize diverse groups into collaborative dialogue. Under NCNU's coordination, interests among astronomers, tourism operators, and government agencies were consolidated. By establishing "how to build a sustainable dark-sky environment" as a common focus, and through structured interaction, the initiative

transformed outdated governance models and spurred tourism reform in Qingjing. These developments introduced a new identity for local tourism, improved stakeholder engagement, and strengthened local participation, leading to a new tourism destination brand.

With dark-sky tourism now serving as a core of Qingjing's tourism development under this cross-sector model, a key challenge remains: how to sustainably expand this initiative to other townships. NCNU plans to continue supporting the county government in cross-regional planning and integration of dark-sky strategies. By conceptualizing and applying the current experience in other regions, the university seeks to broaden the scope of dark-sky development. As stakeholder interests become increasingly complex across regions, NCNU will continue to play a key role in building and sustaining governance networks for local governments.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors Contribution

Both authors contributed equally to the writing of this article. **Y.P.T.** served as the principal executor of the research funding and as the chief consultant for the *Planning and Development Project of Dark-Sky Initiatives* commissioned by the Nantou County Government, and was responsible for the overall conceptual framework of the paper, data analysis, and the drafting of the English manuscript. **Y.Z.J.**, a PhD candidate at National Chi Nan University, was responsible for the literature review, identification of stakeholder roles, preparation of figures and tables, and the development of the study's conclusions and recommendations.

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