

# Astrotourism and sustainable development: A case study of Yoron Island, Kagoshima Prefecture, Japan

Koki Sawada<sup>a,b,\*</sup>, Tatsuki Yonezawa<sup>c</sup>, Masami Okyudo<sup>b,d</sup>

<sup>a</sup>Graduate School of Tourism, Wakayama University, Japan

<sup>b</sup>Center for Tourism Research, Wakayama University, Japan

<sup>c</sup>Kimino Town Misato Observatory, Japan

<sup>d</sup>Faculty of Tourism, Wakayama University, Japan

## Abstract

Astrotourism has begun to attract an increasing number of tourists and academic researchers. It is seen as an innovative form of tourism that contributes to sustainable tourism development based on the 'triple bottom line' concept. It is expected to contribute to the night-time economy, promote educational activities to prevent light pollution, and encourage the inheritance of star lore in the community. We currently practice sustainable development centered on astrotourism on Yoron Island, Kagoshima Prefecture, Japan based on these three pillars, and this report introduces our initiatives.

## Keywords

Astrotourism  
Sustainable tourism development  
Yoron Island  
Light pollution  
Dark sky

## Astrotourism and Sustainable Development

Astrotourism (AT), based on the observers' interest in sky-related activities, has recently garnered attention from tourists and academic researchers (Tapada et al, 2021; Sawada & Okyudo, 2022a). Excessive light pollution due to modernization has made the urbanists value 'darkness' (Edensor, 2017), and has also encouraged the promotion of dark skies initiatives (Bogard, 2013). AT is also believed to contribute to sustainable development (SD) (Blundell et al, 2020; Pásková et al, 2021).

A study on calculating economic benefits in the Colorado Plateau estimated that over the ten years from 2015 to 2024, AT would generate \$5.75 billion in economic spending, contributing to an average of 10,127 additional jobs per year (Mitchell & Gallaway, 2019). Collison & Poe (2013, p. 12) state that the Astronomy/Dark Sky Project at Bryce Canyon National Park is conducive to increasing the number of tourists in the park during the daytime. AT research thus focuses on the creation of new socio-economic benefits in the community.

In terms of environmental sustainability, Weaver (2011) points out that the heavens are too far removed from the observer, therefore, AT would not be ecologically impacted through mere observations. The International Dark-Sky Association (IDA) has identified the promotion of AT and ecotourism as one of its goals in its International Dark-Sky Place Program (IDSP) (International Dark Skies Association, 2018). Furthermore, light pollution researchers who have examined the ecological effects of artificial lighting recognize AT as a vehicle to impart knowledge about the effects of pollution. Therefore, existing studies identify that AT contributes to ecological sustainability while focusing on light pollution.

Regarding the aspect of sociocultural sustainability, Delgeish et al (2020) pointed out that AT provides educational opportunities for tourists and locals, covering topics from astrophysics to indigenous knowledge; and empowers women in rural areas. Escario-Sierra et al (2022) noted that AT

provides opportunities where the locals and public agencies work closely together to protect night skies. AT research thus focuses on social educational effects and indigenous knowledge inheritance related to astronomy.

Most of the previous studies have focused on and advocated AT's contribution to SD. Based on these discussions, this paper introduces Triple Bottom Line (TBL)-based astrotourism development (ATD) as practiced on Yoron Island, Kagoshima Prefecture, Japan.

## Astrotourism Development on Yoron Island

Yoron Island, located on the border between Kagoshima and Okinawa Prefectures in Japan, is surrounded by coral reefs. It has a population of approximately 5,000 inhabitants and an area of 20.58 km<sup>2</sup> (Yoron Town Hall, 2022).

Yoron Island has a history of tourism development since the postwar period. Since the mid-1960s, the island has garnered much interest, especially from urban youth, who enjoy Sun, Sand and Sea (so-called '3S'). The number of tourists on the island increased from 7,994 in 1964 to 150,387 in 1978, and it became crowded with youth from cities (Fumoto, 1985, pp. 695-700). However, with more tourists visiting the island, tourism has had several social impacts as well. For example, water was often cut off because of excessive use by hotels, according to an inhabitant of the island. Since then, due to the tourism industry's growth and development in Okinawa Prefecture and the low cost of overseas travel, the number of tourists is about half of 1987, reaching 70,000 (Yoron Town Hall, 2022). Yoron Town Hall, 2022).

Today, Yoron Island establishes tourism policies aimed at 'SD' rather than 'growth.' This is because it experienced the negative effects of mass tourism. To tackle these issues, the island cannot accept any more tourists due to the lack of human resources. Consequently, the island has shifted its focus to ATD, which uses dark skies as a tourism resource.

In 2019, Yoron Island signed a partnership agreement with the Faculty of Tourism of Wakayama University to launch

\*Corresponding author

Email address: t111055@wakayama-u.ac.jp (K. Sawada)

ATD. This report presents TBL-based (Sharpley & Telfer, 2008) ATD on Yoron Island that the authors are practicing.

*Economic Sustainability*

The island sustains itself economically by creating a night-time economy through AT. The introduction of AT brought new jobs and income opportunities to the island along with more options for nighttime attractions. Currently, about ten operators offer astro-tours on Yoron Island (Table 1). Mr. A, who conducts charter-only tours, makes his living solely from astro-tours. His tour is very popular, as he flexibly changes the contents to meet tourists' needs. 'I want to let everyone know that you can make a living just from dark skies,' says Mr. A.

**Table 1.** The List of Astro-Tour Guides in Yoron Island (made by Authors based on Tourism Association of Yoron Island (2021, p. 9))

No	Astronomy Guide Sommelier® ●: Star Sommelier ○: associate Star Sommelier	tour price/ adult	duration
A	●	¥3,000~	an hour~
B	●	¥3,300	1.5~2.5hours
C	●	¥3,500~	an hour
D	○	¥6,000~	(Photo-tour)
E	○	¥3,300	1.5 hours
F	○	¥3,000~	3 hours
G	○	Volunteer	—

Astronomical guides on the island are generated by the students at Wakayama University and serve as 'the qualification system for the Astronomy Guide (the System)' after their graduation. The system is a training course for star guides conducted in Japan. The program comprises two levels: 'Star Sommelier' and 'Associate Star Sommelier.' To reach the former level, one must have practical experience in touring. So far, four courses have been held on Yoron Island (instructor: Masami Okyudo), and 51 people (Star Sommelier: 4, Associate Star Sommelier: 47) have obtained the qualification. This is about 1% of the population. Mr. B, a Star Sommelier who conducts marine tours during the daytime, said, "You often encounter dangers in the ocean, but no one gets hurt looking at dark skies. In my retirement, I want to spend my life just gazing at the stars." The provision of specialized courses in astronomy generates new socio-economic benefits and helps them find a sense of purpose in their lives.

*Environmental Sustainability*

One aspect of environmental sustainability is our commitment to preventing light pollution. Yoron Island practices two main initiatives. The first is the designation of 'the Model Area for Preserving Dark Skies (the Model Area).' Since March 2021, we are in the process of switching to security lights that meet the standards set by IDA (International Dark-sky Association, 2018, p. 9). While making the switch, the manufacturer of security lights failed to sell the ones that are light-pollution-resistant. Therefore, we fabricated to change the mounting fixtures to be horizontally made. Additionally, the upward light leakage was cut by shielding the photometric parts with an aluminum film. The area within a 500m radius of the *Gusuku* and *Riccho* districts has been designated as the model area and most of the lights have been replaced. These efforts have created a space where security lights and beautiful

starry skies coexist (Figure 1).

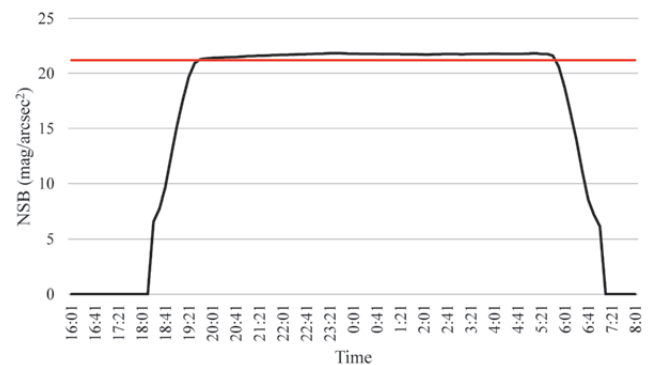


**Figure 1.** The Model Area (Security Lights: upward lighting ZERO & CCT > 3000.) Source: Masami Okyudo

The second initiative is monitoring light pollution. In Yoron Island, a SQM-LE (Sky Quality Meter) is installed in the inner city, the Model Area, and the eastern part of the island to measure night sky brightness (NSB) (Astrotourism Lab, 2022). SQM can continuously quantify the magnitude per square arcsecond ( $\text{mag}/\text{arcsec}^2$ ) at a constant point (Cinzano, 2005). Despite a few disadvantages, it is the most used instrument to measure NSB because of its low cost and the simplicity to quantify (Hänel et al., 2018). Although there are challenges in processing data to detect precise values, such as the scattering of light pollution by clouds and analysis of the effects of the Milky Way brightness, installing SQM has made it possible to monitor the level of environmental change caused by artificial lighting (Figure 2).

As a result of such countermeasures, Yoron Island was reported as 'the least light polluted area in Japan' by the Ministry of the Environment in 2021. Currently, NSB on Yoron Island hovers around 21.7  $\text{mag}/\text{arcsec}^2$  during clear days when the lunar cycle is unaffected, well within IDSP certification criteria of 21.2  $\text{mag}/\text{arcsec}^2$  (Astrotourism Institute, 2022).

The installation of more security lights is an emerging issue on the island. Our survey revealed that more than 600 security lights have been installed on the island. Replacing all of these would be enormously expensive, and it is difficult to obtain agreement from the residents. Another issue is the electric cultivation of flowers and sports activities using nighttime facilities that are visible in the satellite pictures as light pollution. It is necessary to solve these issues in the future while considering the social lives of the inhabitants.



**Figure 2.** The measurement of NSB in the Model Area in 2022, March 3<sup>rd</sup>-4<sup>th</sup> (the red line shows the IDSP certification criteria) Source: Authors

**Socio-Cultural Sustainability**

The socio-cultural sustainability aspect involves two initiatives. We regularly conduct astronomical programs for islanders such as stargazing events for the local children. Those courses are often organized by students of the system. For example, a course combining stargazing and picture book reading is held by some qualified library staff. Additionally, we also offered the residents an observation program for the partial solar eclipse that occurred in 2020 (Figure 3). Offering astronomy education programs for islanders allows them to positively participate in ATD.

Furthermore, we refer to the inheritance of astronomical folklore through AT. Back when clocks or GPS were unavailable, the locals fished and farmed depending on the movement of the celestial bodies. An individual in his 90s vividly remembers the time and direction in which the Pleiades (*Buri-Bushi*) and the Orion Belt (*Michi-Bushi*) appeared, and



**Figure 3.** Observing Solar Eclipse Program on June 21<sup>st</sup>, 2021  
Source: Minami Kobayashi



**Figure 4.** A Music Transcription of the folk song in Yoron Island by Ryusuke Yoneyama (Sawada et al, 2021, p. 78)

he often caught squid when these celestial bodies were visible from the horizon. There are several folk songs on Yoron Island with lyrics relating to astronomy. We have transcribed the songs collected during the interview (Figure 4) and encourage tour operators to actively use these cultural resources. As dialects and cultures are being lost, we seek ways to pass on the culture through AT.

**Conclusions**

In this paper, we briefly reviewed the relationship between AT and SD and introduced our TBL-based initiatives on Yoron Island, Kagoshima Prefecture.

SD has become a widely used term by the public, politicians, and researchers. However, it has also been criticized as a tasteless, bland, and abstract concept (Mowforth & Munt, 2009). To realize SD, the following questions need to be asked reflexively: ‘what is sustainability?’ and ‘who is sustainability for?’ For example, it is difficult for guides to earn a steady income because tour schedules are subject to weather conditions. Therefore, we have introduced an indoor program using *Mitaka* astronomical simulation software. Some residents living in the Model Area have also been critical, remarking that ‘the island has become darker.’ Further research is needed to determine whether AT can truly help realize SD. To conclude this paper, we point out that it is necessary to step away from the shortsighted view that AT contributes to SD, and adopt a reflexive perspective based on ‘what is sustainability.’

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**References**

Astrotourism Lab. (2022, May 7<sup>th</sup>). *Data*. Retrieved September 1<sup>st</sup>, 2022, from <https://astrotourism.jp/data/>

Blundell, E., Schaffer, V., & Moyle, B. (2020). Dark sky tourism and the sustainability of regional destinations. *Tourism Recreation Research*, 45(4), 549-556.

Bogard, P. (2013). *The End of Night: Searching for Natural Darkness in an Age of Artificial Light*. Little, Brown and Company.

Cinzano, P. (2005). Night Sky Photometry with Sky Quality Meter. *ISTIL Internal Report*, 9(1.4), 1-14.

Collison, F., & Poe, K. (2013). “Astronomical Tourism”: The Astronomy and Dark Sky Program at Bryce Canyon National Park. *Tourism Management Perspectives*, 7, 1-15.

Delgeish, H., Mengistie, G., Backes, M., Cotter, G., & Kasai, E. (2020). Dark sky tourism and sustainable development in Namibia. *Education and Heritage in the era of Big Data in Astronomy Proceedings IAU Symposium*, 367, 360-362.

Edson, T. (2017). *From Light to Dark: Daylight, Illumination, and Gloom*. University of Minnesota Press.

Escario-Sierra, F., Álvarez-Alonso, C., Moseñe-Fierro, A., & Sanagustín-Fons, V. (2022). Sustainable Tourism, Social and Institutional Innovation-The Paradox of Dark Sky in Astrotourism. *Sustainability*, 14(11), 6419.

Fumoto, S. (1988). Kanko [Tourism]. In Yoron-Cho Shi Editorial Board (Ed.). *Yoron-Cho Shi [Yoron Town History]* (pp. 695-732). Education Board of Yoron Town.

- Hänel, A., Posch, T., Ribas, S., Aubé, M., Duriscoe, D., Jechow, A., Kollath, Z., Lolkema, D., Moore, C., Schmidt, N., Spoelstra, H., Wuchterl, G., & Kyba, C. (2018). Measuring night sky brightness: methods and challenges. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 205, 278-290.
- International Dark-Sky Association. (2018, June). International Dark Sky Park program Guidelines. Retrieved September 1<sup>st</sup>, 2022, from <https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/2018/12/IDSP-Guidelines-2018.pdf>
- Ministry of the Environment. (2021, December 24<sup>th</sup>). The Research Result of Night Sky Brightness. Retrieved September 1<sup>st</sup>, 2022, from <https://www.env.go.jp/content/900518743.pdf>
- Mitchell, D., & Gallaway, T. (2019). Dark sky tourism: economic impacts on the Colorado Plateau Economy, USA. *Tourism Review*, 74(4), 930-942.
- Mowforth, M., & Munt, I. (2009). *Tourism and Sustainability: Development globalisation and new tourism in the Third World*. Third Edition. Routledge.
- Pásková, M., Budinská, N., & Zelenka, J. (2021). Astrotourism-Exceeding Limits of the Earth and Tourism Definitions? *Sustainability*, 13(1), 373.
- Sawada, K., Kitao, K., Yoneyama, R., & Okyudo, M. (2021). Yoron-Jima ni okeru Hoshi Bunka to sono Kanko Katsuyo ni mukete no Ichi-Kosatu [A study on star lore in Yoron Island, Kagoshima prefecture]. *Tourism Studies*, 25, 69-82.
- Sawada, K., & Okyudo, M. (2022a). Exploring the astro-tourism space: A review of the English literature to build a research framework in Japan. *Tourism Studies*, 26, 85-102.
- Sawada, K., & Okyudo, M. (2022b). Astrotourism development in Yoron Island, Japan: Perspectives and Potential. *General Assembly International Astronomy Union Abstract Book*, 32, 1261.
- Sawada, K., & Okyudo, M. (2022c). Astrotourism and Sustainability: A case study of Yoron Island, Kagoshima Prefecture. *International Conference on Geoscience Education Proceedings*, 9, 34. [https://www.geoscienced9.org/\\_files/ugd/f1d967\\_dc406ce8437a487d87079e97ccbda2c7.pdf](https://www.geoscienced9.org/_files/ugd/f1d967_dc406ce8437a487d87079e97ccbda2c7.pdf)
- Sharpley, R., & Telfer, D. (2008). *Tourism and Development in the Developing World*. Routledge.
- Tapada, A., Marques, C., & Costa, C. (2021). Astrotourism: A Literature Review and Framework for Future Research. *Enlightening Tourism. A Pathmaking Journal*, 11(2), 291-331.
- Tourism Association of Yoron Town. (2021, November). Yoron Island PICHU vol. 3. Retrieved August 31<sup>st</sup>, 2022, from [https://drive.google.com/file/d/1kpcVKcbhA8k\\_EuFPkxHB4DZLfXo03xH-/view?usp=sharing](https://drive.google.com/file/d/1kpcVKcbhA8k_EuFPkxHB4DZLfXo03xH-/view?usp=sharing)
- Weaver, D. (2011). Celestial ecotourism: new horizons in nature-based tourism. *Journal of Ecotourism*, 10(1), 38-45.
- Yoron Town Hall. (2022, March 10th). *Chosei Yoron [A Statistical Survey of Yoron Town]*. Retrieved August 31<sup>st</sup>, 2022, from [https://www.yoron.jp/common/UploadFileDsp.aspx?c\\_id=22&id=47&flid=17](https://www.yoron.jp/common/UploadFileDsp.aspx?c_id=22&id=47&flid=17)



**Koki Sawada** is pursuing a master's in tourism at Wakayama University in Japan and is a visiting junior fellow at the Center for Tourism Research at the same university. He has been engaged in astrotourism development in several Japanese areas, especially Yoron Island, and Kagoshima Prefecture. His current research interest includes the social history of astrotourism in Japan, cultural studies in tourism, and virtual reality in tourism. His recent work was published in *Tourism Studies Review* published by the Japan Society for Tourism Studies (written in Japanese).



**Tatsuki Yonezawa** is a researcher at Kimino Town Misato Observatory, Wakayama Prefecture, Japan. He joined the Kimino Town Misato observatory in 2021. He worked as a Japanese map publisher for several years after completing his bachelor's at Wakayama University, Japan. He has been engaged in the editorial committee at *White Paper on Japanese Public Observatory 2018*. His current interests include astrotourism, geographic information systems in tourism, and big data.



**Masami Okyudo** is a professor in the Faculty of Tourism of Wakayama University in Japan (Dean) and research staff in the Center for Tourism Research at the same University. He joined Wakayama University in 2003 after completing his Ph. D. at Saga University in Japan. He worked in several public observatories in Japan for over a decade. His current research interests include astrotourism, human engineering, ICT, and virtual reality in tourism.