

Mainstreaming Astrotourism: Lessons from Malaysia and their Adaptation Potential in Uzbekistan

RoZIAH Sidik @ Mat Sidek

Institute of Islam Hadhari, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia &
Research Centre for Arabic Language and Islamic Civilization, Faculty of Islamic Studies, Universiti
Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

DOI: <https://doi.org/10.47772/IJRISS.2026.100801066>

Received: 12 September 2026; Accepted: 17 September 2026; Published: 24 September 2026

ABSTRACT

Astrotourism has emerged as a distinctive form of special-interest tourism that combines night-sky observation with nature, science, education, culture and increasingly heritage-based experiences. This article examines Malaysia's emerging experience in developing astrotourism and assesses the adaptation potential of selected practices to Uzbekistan. Using qualitative comparative document analysis, Malaysia is treated as a reference case and Uzbekistan as a prospective adaptation case. The revised analysis applies a comparative adaptation matrix across six contextual dimensions, namely environmental, socioeconomic, cultural, infrastructural, technological and governance dimensions, and integrates them with seven dimensions of astrotourism development: astronomical resources, heritage narratives, observatory tourism, knowledge tourism, digital integration, community participation and destination networking. The Malaysian experience demonstrates the value of combining dark-sky resources, astronomy education, Islamic astronomical narratives and stakeholder collaboration, while also revealing constraints involving light pollution, infrastructure, awareness and specialised human capital. Uzbekistan offers a complementary context through the internationally significant legacy of Ulugh Beg and the Samarkand Observatory. The article proposes a Malaysia-Uzbekistan Astrotourism Adaptation Framework, a set of readiness and sustainability indicators, and a pilot application centred on Samarkand to demonstrate how Malaysian lessons may be selectively adapted rather than replicated. The study advances heritage-based astrotourism as a pathway that integrates contemporary sky observation with the scientific and civilisational history of astronomy and provides an operational agenda for subsequent stakeholder-based empirical validation.

Keywords: astrotourism, Islamic astronomy, astronomical heritage, heritage tourism, Uzbekistan

INTRODUCTION

Contemporary tourism has become increasingly diversified as travellers seek experiences that extend beyond conventional sightseeing towards forms of travel offering participation, learning and meaningful engagement with place. Experiential, nature-based, educational and special-interest tourism have consequently become increasingly important in destination development, particularly where destinations are able to transform distinctive natural or cultural resources into memorable visitor experiences. Within this changing landscape, astrotourism has emerged as a tourism segment centred on the night sky, celestial phenomena and astronomy-related activities. It has been conceptualised as a form of nature-based and special-interest tourism in which tourists travel specifically to engage with sky-related experiences, particularly dark-sky observation and astrophotography (Soleimani et al., 2019). Fayos-Solá et al. (2014) further emphasise its capacity to connect astronomical observation with meaningful scientific and tourism experiences, while Escario-Sierra et al. (2022) position astrotourism within sustainable tourism development. Taken together, these perspectives indicate that astrotourism should not be understood simply as recreational stargazing, but as a tourism form capable of combining environmental resources, scientific interest and experiential value.

The environmental foundation of astrotourism nevertheless remains important because the visibility of celestial phenomena depends substantially on the quality of the night sky. Artificial lighting can reduce night-sky visibility and diminish the very resource on which many astronomical experiences depend, making light

pollution a major challenge to destination development (Kanianska et al., 2020; Escario-Sierra et al., 2022). The preservation of dark skies has therefore become closely associated with sustainable astrotourism, environmental governance and the development of rural or less urbanised destinations. Yet an exclusive emphasis on darkness risks reducing astrotourism to the physical conditions required for observation. Astronomy is also embedded in human scientific and cultural history. The ICOMOS-International Astronomic-

al Union thematic study demonstrates that astronomical heritage encompasses monuments, sites, instruments, archaeological remains, scientific knowledge and cultural relationships with the sky (Ruggles and Cotte, 2010). This suggests that destinations may derive astrotourism value not only from what visitors can observe in the contemporary sky, but also from the historical meanings, scientific practices and cultural narratives through which societies have understood that sky.

This broader conception is particularly relevant to Muslim societies because astronomy occupied an important position within Islamic civilisation as both a scientific discipline and a field connected with practical religious and social requirements, including prayer times, qibla determination and calendrical practices. The development of observatories, astronomical instruments and scholarly networks demonstrates that engagement with the sky formed part of a wider intellectual tradition rather than an isolated observational activity. Such a legacy creates a basis for tourism experiences in which contemporary astronomy can be interpreted through the history of science, religion, culture and civilisation. In this context, astronomical heritage can deepen the experiential content of astrotourism by allowing visitors to encounter not only celestial objects but also the knowledge traditions, institutions and historical actors associated with their observation and interpretation. This heritage dimension is particularly important to the present study because it provides the conceptual bridge between Malaysia's emerging experience of Islamic astrotourism and Uzbekistan's much deeper place-based astronomical heritage.

Malaysia provides an instructive reference case because its emerging astrotourism landscape combines several resource types rather than depending on a single attraction. Islamic astrotourism has been conceptualised in Malaysia as tourism involving astronomical, historical and archaeological sites such as observatories, mosques, museums and planetariums (Safiai et al., 2020), while subsequent studies have examined its environmental, sustainability and tourism-development potential (Faid et al., 2022; Hanafiah et al., 2025; Ahmad et al., 2026). Observatories and falak complexes also provide institutional settings in which astronomy education, Islamic astronomical knowledge and tourism activities can intersect (Dimyati and Safiai, 2024). At the same time, Malaysian experience demonstrates that possessing astronomical resources is insufficient to establish a viable destination. Light pollution, accessibility, infrastructure, destination awareness and stakeholder coordination continue to constrain development (Hanafiah et al., 2025; Ahmad et al., 2026). Malaysia is therefore useful not because it represents a completed model of mainstream astrotourism, but because it reveals both the opportunities and the developmental mechanisms required to move from isolated astronomy-related attractions towards a more integrated tourism ecosystem.

Uzbekistan offers a contrasting but complementary context for examining the transferability of these lessons. Its comparative advantage lies less in reproducing Malaysia's emerging products than in mobilising an extraordinary historical relationship with astronomy. The fifteenth-century observatory of Ulugh Beg in Samarkand represents what Zotti and Mozaffari (2020) describe as the culmination of the development of astronomical observatories in the Islamic world, while its surviving remains and monumental astronomical instrument provide tangible connections to the scientific achievements of Timurid Samarkand. This creates a different developmental proposition. Whereas Malaysia illustrates how astronomy-related resources, education and stakeholder participation can be assembled into an emerging astrotourism ecosystem, Uzbekistan possesses an internationally significant civilisational asset around which heritage interpretation, science tourism and contemporary astronomical experiences could potentially be integrated. The relationship between the two cases is therefore one of selective adaptation rather than direct replication.

Despite growing scholarship on astrotourism, dark-sky tourism and sustainable destination development, considerably less attention has been devoted to the relationship between astrotourism and Islamic astronomical heritage, particularly from a cross-country adaptation perspective. Existing studies predominantly examine natural night-sky resources, tourist motivations, light pollution, sustainability or destination development

(Soleimani et al., 2019; Kanianska et al., 2020; Escario-Sierra et al., 2022). Malaysian scholarship has begun to incorporate Islamic astronomy into the conceptualisation of astrotourism (Safiai et al., 2020), but the question of how developmental experience from an emerging astrotourism context might be selectively adapted to a destination possessing major historical astronomy assets remains underexplored. Addressing this gap is important because it shifts the discussion from whether a destination possesses suitable astronomical resources to how different combinations of environmental, scientific and heritage resources can be transformed into distinctive tourism experiences.

Against this background, this article asks which elements of Malaysia's emerging astrotourism experience can be adapted to Uzbekistan and how those elements can be contextualised within Uzbekistan's distinctive Islamic astronomical and Silk Road heritage. It pursues three objectives: to identify the principal characteristics, opportunities and challenges emerging from Malaysia's astrotourism experience; to examine Uzbekistan's comparative advantages for heritage-based astrotourism; and to develop a strategic adaptation framework connecting relevant Malaysian experience with the Uzbek context. The central argument is that Malaysia should be treated as a developmental reference rather than a replicable model. Malaysia provides experience in building the ecosystem surrounding astrotourism, whereas Uzbekistan provides exceptional civilisational and heritage depth. Bringing these two dimensions together enables the article to advance heritage-based astrotourism as a complementary pathway to conventional dark-sky astrotourism and to consider its implications for Uzbekistan's destination positioning.

ASTROTOURISM: FROM DARK-SKY TOURISM TO KNOWLEDGE AND HERITAGE TOURISM

Astrotourism as Special-Interest and Sustainable Tourism

Astrotourism occupies the intersection of several tourism categories. Soleimani et al. (2019) position it within special-interest and nature-based tourism, emphasising tourists' interest in activities involving the sky and the possibility of combining terrestrial destination characteristics with celestial features. Darkness constitutes the fundamental environmental resource for many astrotourism experiences. Kanianska et al. (2020) demonstrate that landscape potential and night-sky quality are important determinants of astrotourism development and that artificial illumination associated with urbanisation can substantially diminish this resource. Escario-Sierra et al. (2022) similarly argue that astrotourism can contribute to sustainable territorial development but requires interaction among public authorities, communities and other stakeholders. Recent Malaysian evidence reinforces this relationship: Ahmad et al. (2026) identify community participation, zoning, infrastructure and education as relevant elements in conserving dark skies, while Faid et al. (2022) connect Malaysian astrotourism potential with economic, wellbeing and biodiversity dimensions of sustainability.

Astrotourism as Knowledge Tourism

Astrotourism also possesses an important educational dimension. Tourists do not simply consume visual landscapes; astronomical experiences can expose them to scientific concepts, observational techniques and understandings of the universe. This places astrotourism within the broader domain of science and knowledge tourism. Cooper et al. (2026) define science tourism as a primarily tourism-oriented experience involving engagement with scientific knowledge while remaining distinct from formal education and professional scientific travel. A guided observation session may explain constellations, planetary motion or astronomical instruments, while an observatory visit can expose visitors to scientific processes and the history of astronomical knowledge. Tourism value therefore arises not only from seeing the sky but also from understanding it. This article consequently conceptualises astrotourism as knowledge-based experiential tourism when astronomical observation is accompanied by scientific, historical or cultural interpretation.

Astronomical Heritage as a Tourism Resource

Ruggles and Cotte (2010) demonstrate that astronomical heritage encompasses sites and cultural properties reflecting relationships between human societies and the sky. Such heritage can include physical structures, astronomical instruments, archaeological evidence and associated knowledge. Historic observatories can

therefore retain scientific and cultural significance even when they no longer function as operational research facilities. Conventional dark-sky astrotourism primarily centres on the observation of the night sky, where the quality of darkness enables visitors to engage directly with celestial phenomena and derive meaningful tourism experiences. The integration of astronomical heritage adds further dimensions to this experience by incorporating the interpretation of historical sites, instruments and knowledge traditions. Visitors are therefore able not only to observe the night sky but also to understand its historical and scientific significance, thereby

creating a more knowledge-rich and culturally meaningful astrotourism experience. This article uses the term heritage-based astrotourism to describe tourism experiences in which astronomical observation or interest in the sky is integrated with tangible or intangible heritage relating to the historical development, practice and cultural meaning of astronomy.

METHODOLOGY

This study adopts qualitative comparative document analysis to examine the potential transferability of astrotourism development experience between Malaysia and Uzbekistan. Document analysis is appropriate where research seeks to interpret existing scholarly literature, institutional documentation and recorded experience systematically rather than generate new primary data (Bowen, 2009). The comparative design is deliberately asymmetrical: Malaysia is treated as a reference case, whereas Uzbekistan is treated as a prospective adaptation case. The purpose is not to compare national tourism performance or establish equivalence between the two countries, but to identify practices and developmental mechanisms emerging from Malaysia and assess the conditions under which they may be adapted to Uzbekistan's distinctive historical, environmental and tourism context.

The Malaysian analysis draws upon published studies concerning Islamic astrotourism, sustainability, visitor interest, barriers, destination development, observatory-based tourism and dark-sky conservation (Safiai et al., 2020; Faid et al., 2022; Dimyati and Safiai, 2024; Hanafiah et al., 2025; Ahmad et al., 2026). These studies provide evidence of resource potential, market interest and developmental constraints within an emerging astrotourism sector. The Uzbekistan component focuses on scholarly and heritage documentation relating to Ulugh Beg, the Samarkand Observatory and astronomical heritage, particularly the ICOMOS-IAU thematic study and historical research concerning the observatory and its principal instrument (Ruggles and Cotte, 2010; Zotti and Mozaffari, 2020). The two evidence bases are therefore used for different analytical purposes: Malaysian studies provide developmental lessons, while the Uzbekistan literature establishes the heritage and destination context against which transferability is assessed.

The analysis proceeded through four stages. First, recurring dimensions of astrotourism development were identified from the Malaysian and international literature. Second, the transferability of Malaysian experience was assessed through a six-dimensional contextual matrix covering environmental conditions, socioeconomic value, cultural and heritage fit, infrastructure and accessibility, technological capacity, and governance and stakeholder coordination. Third, these contextual conditions were integrated with seven astrotourism development dimensions: astronomical and environmental resources; heritage and cultural narratives; astronomy infrastructure and observatory tourism; education and knowledge tourism; digital integration; community and industry participation; and destination positioning and networking. Fourth, the framework was operationalised through proposed readiness and sustainability indicators and a pilot application to Samarkand. The resulting framework remains conceptual and strategic rather than empirically validated in Uzbekistan. No new primary data were collected because the study was designed as comparative document analysis; accordingly, the indicators and pilot application are formulated as testable propositions for subsequent validation through tourist surveys, interviews with destination managers and government stakeholders, community consultation, site assessment and feasibility analysis.

MALAYSIA AS AN EMERGING ASTROTOURISM REFERENCE CASE

Resource Base and Emerging Value Proposition

Malaysia possesses several characteristics favourable to astrotourism. Natural landscapes including islands,

beaches, national parks, highlands and rural areas provide potential environments for stargazing and astrophotography. Faid et al. (2022) demonstrate the relationship between areas relatively free from light pollution and the possibility of integrating astrotourism with sustainability objectives. The Malaysian astrotourism landscape, however, extends beyond natural dark-sky locations. Observatories and falak complexes provide physical infrastructure capable of supporting astronomical education and visitor experiences. Dimyati and Safiai (2024), for example, examine the tourism role of Kompleks Falak Al-Khawarizmi in Melaka and highlight its interconnected functions of research, education and tourism. Malaysia also possesses an established Islamic astronomy tradition, and Safiai et al. (2020) argue that Islamic astrotourism can incorporate observatories, mosques, museums, planetariums and archaeological sites associated with astronomical knowledge. Taken together, these resources indicate that Malaysia's potential lies not in a single type of attraction but in the possibility of combining natural environments, astronomical infrastructure, Islamic knowledge and educational interpretation within a differentiated tourism experience.

Evidence of market interest supports this broader value proposition. Hanafiah et al. (2025), based on 117 respondents, identify a notable gap between interest in astronomy-related tourism and actual participation: 61.5% of respondents expressed interest in astronomy, only 13.7% had previously participated in astrotourism activities, and 88% indicated willingness to join astrotourism packages. The significance of this gap is analytical rather than merely descriptive. Limited previous participation does not necessarily indicate weak demand; it may instead reflect the limited visibility, accessibility or availability of well-developed products. Malaysian studies also connect astrotourism with economic activity, education, environmental awareness and community engagement (Faïd et al., 2022; Hanafiah et al., 2025; Ahmad et al., 2026). The emerging value proposition is therefore multidimensional, combining experiential appeal with opportunities for knowledge acquisition and sustainability-oriented destination development.

Constraints and Ecosystem Development

Malaysia's experience demonstrates several barriers to transforming astrotourism from an emerging niche into a more established tourism product. High-quality night skies are sensitive to artificial illumination (Kanińska et al., 2020), and Malaysian research similarly identifies artificial lighting and development pressure as threats to dark-sky conservation (Ahmad et al., 2026). Darker locations may also be situated away from major urban centres, making transportation, accommodation, safety and basic amenities important; Hanafiah et al. (2025) identify accessibility and amenities among relevant considerations affecting participation. The gap between expressed interest and previous participation further indicates that resource availability alone is insufficient without stronger destination communication, product development and marketing. In addition, effective interpretation requires human capital capable of explaining astronomical phenomena while connecting them with local history, culture and heritage. These constraints reveal that mainstreaming astrotourism is simultaneously an environmental, infrastructural, interpretive and institutional challenge.

The implication is that astrotourism should be developed as an integrated ecosystem rather than as a collection of isolated stargazing sites. Observatories and falak complexes can serve as educational and interpretive anchors, while dark-sky environments provide the observational resource around which visitor activities are organised. Tourism operators connect these resources to markets, local communities can provide accommodation, food, transport and complementary experiences, and universities or astronomy organisations can contribute scientific expertise and guide training. Digital technology can support this network because astrotourism is highly sensitive to location, timing and environmental conditions. In this article, digital integration is therefore treated not as an established Malaysian outcome but as a strategic development principle arising from the wider ecosystem approach. The central lesson from Malaysia is that the viability of astrotourism depends less on the existence of a single attractive site than on the capacity to coordinate resources, interpretation, infrastructure and stakeholders around a coherent visitor experience.

UZBEKISTAN AND THE POTENTIAL FOR HERITAGE-BASED ASTROTOURISM

Civilisational and Astronomical Heritage

Uzbekistan presents a fundamentally different resource configuration from Malaysia. Its principal comparative

advantage lies in the historical depth and authenticity of its astronomical heritage. Samarkand was an important centre of scientific activity during the Timurid period, and the observatory established under Ulugh Beg in the 1420s became one of the major astronomical institutions of the Islamic world. Zotti and Mozaffari (2020) describe it as representing the culmination of the development of astronomical observatories in the Islamic world. Its significance lies not merely in the survival of archaeological remains but in the scientific practices associated with the site. The monumental meridian instrument supported precise observations, while the scholarly environment surrounding Ulugh Beg brought together astronomical observation, mathematical calculation and instrumentation. Ruggles and Cotte (2010) situate the Ulugh Beg Observatory within the broader field of astronomical heritage. For tourism development, this combination of physical remains, scientific achievement and civilisational memory provides a resource that is difficult to reproduce elsewhere and therefore offers Uzbekistan a distinctive basis for heritage-based astrotourism.

Translating Astronomical Heritage into Tourism Experience

Astronomical heritage becomes a tourism resource only when historical and scientific knowledge is translated into an accessible visitor experience. Interpretation is therefore central to the transformation of the Ulugh Beg Observatory from a historic monument into an astrotourism asset. The scientific significance of a monumental meridian instrument may be readily understood by historians of astronomy but not necessarily by ordinary visitors. Interpretation can explain how astronomers observed celestial objects before modern telescopes, why very large instruments were constructed, how stellar positions were measured and how observations contributed to astronomical tables. Zotti and Mozaffari (2020) demonstrate that virtual reconstruction can contribute to understanding the form and operation of the observatory's principal instrument. When such interpretation is linked with contemporary observation, visitors can move from encountering a historic site to understanding its scientific significance and then to experiencing the night sky through a historically informed perspective. The tourism value therefore arises from the relationship between place, knowledge and observation rather than from the monument or night sky in isolation.

This interpretive approach also allows astronomical heritage to be incorporated into Uzbekistan's established Silk Road tourism identity. The Silk Road was not simply a route through which commodities circulated; it also facilitated encounters among societies and the movement of ideas, technologies and knowledge. Astronomy can therefore add a scientific and intellectual layer to a tourism narrative that is often dominated by architecture, trade and political history. Positioning Samarkand's astronomical heritage within this wider context enables visitors to understand the city not only as a historic destination but also as a centre of knowledge production and scientific exchange. Astrotourism in Uzbekistan need not consequently emerge as an isolated niche. It can operate at the intersection of Islamic heritage tourism, Silk Road tourism, science tourism and contemporary astronomical experience, thereby extending the interpretive depth of an already established destination identity.

ADAPTING MALAYSIAN EXPERIENCE TO UZBEKISTAN

Heritage Interpretation and Observatory-Based Experience

Malaysia demonstrates the potential to integrate Islamic astronomical narratives with tourism (Safiai et al., 2020), but the Uzbek context permits a more strongly place-based application of this principle. In Malaysia, Islamic astronomy can provide a cultural and educational narrative connecting observatories, religious practices and astronomical knowledge. In Uzbekistan, equivalent interpretation can be anchored directly to internationally significant historical personalities, scientific institutions and material remains. Ulugh Beg, the Samarkand Observatory and the intellectual environment of Timurid Central Asia provide a historically specific narrative through which visitors can encounter Islamic astronomy as knowledge produced in a particular place and period. Adaptation therefore requires more than transferring an Islamic astronomy theme from one destination to another. The narrative must be reconstructed around Uzbekistan's own historical evidence so that heritage interpretation strengthens authenticity rather than producing a generic account of Islamic scientific achievement.

A similar distinction applies to observatory-based tourism. Malaysian falak complexes demonstrate that

astronomical institutions can support research, education and tourism simultaneously (Dimiyati and Safiai, 2024). In Uzbekistan, however, the Ulugh Beg Observatory is not primarily valuable because it can reproduce the functions of a contemporary observatory. Its comparative advantage lies in enabling visitors to encounter the historical practice of astronomy through instruments, scientific methods and the intellectual setting in which observations were made. Observatory tourism can therefore be adapted into observatory heritage tourism, with the site functioning as an anchor for interpretation of astronomical measurement, mathematical knowledge and scientific practice. This shift illustrates the broader principle of contextual adaptation: the developmental mechanism may be transferable, but the tourism experience should be constructed from the destination's own resource base and historical identity.

Knowledge Tourism and Digital Interpretation

The educational orientation of Malaysian astrotourism provides another transferable principle. Cooper et al. (2026) offer a wider conceptual basis for tourism experiences in which engagement with scientific knowledge forms part of the visitor experience without becoming formal education. Applied to Uzbekistan, this principle could support the development of Islamic science tourism in which observatory visits are combined with explanations of mathematical astronomy, demonstrations of historical instruments, astronomy workshops and contemporary sky observation. Such products would allow the destination to appeal beyond dedicated astronomy enthusiasts by engaging students, educational groups, Muslim travellers, heritage tourists and visitors interested in the history of science. More importantly, education would not function merely as an additional activity attached to sightseeing. It would become the mechanism through which visitors understand why the astronomical heritage of Samarkand is historically significant and how it relates to broader developments in Islamic civilisation and the history of astronomy.

Digital integration can reinforce this knowledge-based experience when it is used to address the interpretive challenges of complex scientific heritage. Digital platforms could support astronomy trails, historical narratives, event information and educational materials, while augmented or virtual interpretation could help visitors visualise the original appearance and operation of the Samarkand Observatory. Zotti and Mozaffari's (2020) virtual reconstruction of the principal instrument provides a scholarly foundation for such interpretation. The strategic value of digital technology therefore lies less in technological novelty than in its capacity to make otherwise inaccessible scientific processes visible and understandable. It can bridge the gap between surviving archaeological remains and the sophisticated astronomical practices once carried out at the site. Technology should consequently complement rather than replace the authentic heritage environment, strengthening the connection between evidence, interpretation and visitor understanding.

Community Value Chains, Silk Road Integration and Destination Networks

Community participation is another important lesson emerging from Malaysian research (Hanafiah et al., 2025; Ahmad et al., 2026). In Uzbekistan, local communities, guides, artisans, educational institutions and tourism operators could participate in astronomy-related products through roles that extend beyond the heritage site itself. Specialised guides could combine historical interpretation with basic astronomical knowledge, while local businesses could provide accommodation, food, transportation and complementary cultural experiences. This approach would distribute tourism value across a broader local economy and reduce the risk of treating astrotourism as a self-contained attraction. Community participation is therefore not only a sustainability consideration but also part of the mechanism through which an astronomy heritage product becomes embedded within the destination economy.

Integration with the Silk Road provides the second element of this wider value chain. In Malaysia, astrotourism can complement nature-based tourism, ecotourism and Islamic tourism; in Uzbekistan, the comparable strategy is to connect astronomy with existing heritage routes and visitor flows. Astronomical heritage can add a scientific and intellectual dimension to conventional Silk Road interpretation, allowing visitors travelling between historic centres to encounter astronomy as part of a broader narrative of civilisation, knowledge and intellectual exchange. Such integration is strategically important because it does not require Uzbekistan to build an entirely separate tourism market from the beginning. Instead, astrotourism can deepen and diversify established tourism experiences by adding a thematic layer that is closely tied to the historical

identity of Samarkand and the wider region.

Destination networking can extend this integration beyond the national tourism system. Astronomical heritage is inherently transnational because the history of astronomy involved the movement of scholars, instruments, texts and ideas across regions. Uzbekistan could therefore develop collaboration involving universities, observatories, museums and heritage institutions associated with the history of Islamic astronomy. Such networks could support scholarly exchange, exhibitions, educational programmes, specialised tourism

itineraries and international visibility. In strategic terms, networking would help position Uzbekistan not simply as a location containing an important observatory but as an active node within a wider geography of astronomical heritage. This strengthens the case for destination positioning based on Islamic scientific civilisation while remaining consistent with the broader Silk Road narrative of cross-cultural and intellectual exchange.

COMPARATIVE ADAPTATION ASSESSMENT

Transferability across national contexts depends on the extent to which developmental practices correspond with local environmental, socioeconomic, cultural, infrastructural, technological and governance conditions. Accordingly, Malaysian experience is assessed across these six contextual dimensions to distinguish between practices that may be adopted with limited modification, those requiring selective adaptation and those requiring substantial contextual redesign in Uzbekistan. This comparative assessment separates the underlying developmental principle from the local conditions necessary for implementation and clarifies how Uzbekistan's resource configuration may strengthen, modify or constrain the applicability of Malaysian lessons.

Contextual dimension	Relevant Malaysian lesson	Uzbekistan adaptation assessment	Adaptation implication
Environmental	Dark-sky quality, light-pollution control and suitable observation environments are foundational to viable night-sky experiences.	Night-sky observation should complement, rather than substitute for, Uzbekistan's stronger heritage proposition. Site-level darkness, seasonal conditions and lighting pressures require assessment before product development.	Selective adaptation: apply dark-sky management and site-assessment principles to locations linked to the heritage itinerary.
Socioeconomic	Astrotourism can support local economic activity through guiding, accommodation, transport, food and complementary services.	Samarkand already receives heritage visitors, creating opportunities to extend length of stay and distribute spending through astronomy-related services and local enterprises.	Adapt through local value chains, guide specialisation and community-linked products rather than isolated attractions.
Cultural and heritage	Islamic astronomy narratives can differentiate astrotourism and connect observation with religious, scientific and civilisational knowledge.	Uzbekistan possesses a stronger place-based historical anchor through Ulugh Beg, Timurid science and the Samarkand Observatory.	High applicability, but narratives must be reconstructed from Uzbek historical evidence and integrated with Silk Road interpretation.
Infrastructure	Accessibility, amenities, safety, observatory facilities and visitor services affect participation and product viability.	Existing heritage-tourism infrastructure provides a base, but night-time transport, observation facilities, safety, accessibility and visitor amenities require destination-level audit.	Selective adaptation through an infrastructure-readiness assessment focused on night-time and astronomy-specific needs.

Technological	Digital information can connect locations, timing, interpretation and visitor services; virtual tools can strengthen complex scientific interpretation.	Digital reconstruction is especially relevant to explaining the original form and operation of the Samarkand Observatory and its principal instrument.	Strong adaptation potential through multilingual interpretation, virtual reconstruction, astronomy trails and event information.
Governance	Astrotourism requires coordination among tourism agencies, astronomy institutions, universities, communities and operators.	Implementation would require coordination among heritage authorities, tourism bodies, local government, universities, museums, guides and community actors.	Adapt through a destination-level coordinating mechanism with defined conservation, tourism, education and community roles.

Table 1: Comparative Contextual Assessment of Malaysian Astrotourism Lessons for Uzbekistan

MALAYSIA-UZBEKISTAN ASTROTOURISM ADAPTATION FRAMEWORK

Building on the contextual assessment, this article proposes a seven-dimensional Malaysia-Uzbekistan Astrotourism Adaptation Framework. The framework rests upon one central principle: transferability does not mean replication. Malaysia provides experience in developing the ecosystem surrounding astrotourism, including resource mobilisation, education, stakeholder participation and tourism integration, while Uzbekistan possesses a particularly strong historical and civilisational resource base. Each dimension identifies an aspect of Malaysian experience, specifies its reinterpretation in Uzbekistan and links it to an intended strategic outcome. Read together with the six contextual dimensions in Table 1, the framework functions as a contextual translation mechanism rather than a blueprint for reproducing Malaysian astrotourism products.

Dimension	Malaysian Experience	Adaptation Potential in Uzbekistan	Strategic Outcome
Astronomical resources	Dark-sky locations, stargazing and astrophotography	Combine observation environments with historic astronomy sites	Integrated sky-and-heritage experience
Islamic astronomy narrative	Falak, qibla, calendar and Islamic astronomy	Ulugh Beg and the Samarkand astronomical tradition	Authentic civilisational storytelling
Observatory tourism	Falak complexes integrating research, education and tourism	Ulugh Beg Observatory as an anchor heritage attraction	Observatory heritage tourism
Knowledge tourism	Astronomy education and experiential learning	Islamic science and history-of-astronomy experiences	Knowledge-based tourism
Digital integration	Information and interpretation supporting the visitor ecosystem	Virtual reconstruction, smart interpretation and astronomy trails	Digitally enhanced heritage experience
Community participation	Communities, astronomy organisations and tourism operators	Local guides, educational institutions, artisans and tourism businesses	Local tourism value chain
Destination networking	Integration with nature-based and Islamic tourism	Silk Road integration and international astronomy heritage networks	Global destination positioning

Table 2: Malaysia-Uzbekistan Astrotourism Adaptation Framework

ASTROTOURISM READINESS AND SUSTAINABILITY INDICATORS

For the adaptation framework to support destination planning, its dimensions need measurable indicators. Table 3 proposes an initial indicator set that can be used in a future baseline assessment and subsequent monitoring. The indicators are intentionally operational: they cover destination readiness, sustainability, community benefits and dark-sky conservation, while retaining the heritage and knowledge dimensions that distinguish the Uzbek proposition. Thresholds should be established only after local baseline data are collected; the present study therefore specifies what should be measured rather than imposing unvalidated numerical cut-offs.

Assessment domain	Proposed indicators	Illustrative measurement
Astrotourism readiness	Night-sky quality; seasonal observation suitability; site accessibility; night-time transport; safety; accommodation and basic amenities; availability of astronomy-trained guides; visitor information.	Site audit, sky-quality measurement, service inventory, accessibility assessment and guide-capacity inventory.
Heritage and cultural readiness	Authenticity and integrity of astronomy heritage; quality of interpretation; linkage between heritage site and contemporary observation; multilingual content; integration with Silk Road and Islamic science narratives.	Heritage interpretation audit, visitor comprehension survey and expert review.
Technological readiness	Digital visitor information; event/calendar functionality; virtual or augmented interpretation; online booking/information integration; multilingual digital access.	Digital service audit, user testing and platform analytics.
Governance readiness	Existence of coordinating body; clarity of institutional roles; stakeholder participation; conservation-tourism protocols; data-sharing and monitoring arrangements.	Stakeholder mapping, governance document review and manager interviews.
Sustainability	Light-pollution trend; waste and site-management practices; visitor pressure on heritage assets; use of local suppliers; seasonality management.	Periodic environmental monitoring, heritage-condition assessment and operator reporting.
Community benefits	Local employment; local guide participation; local procurement; community-owned products/services; resident perceptions; distribution of tourism spending.	Community survey, business survey, employment/procurement records and stakeholder interviews.
Visitor and market performance	Awareness; intention to participate; satisfaction; learning outcomes; willingness to recommend; repeat/extended-stay intention; package uptake.	Tourist survey, ticket/package data, visitor observation and post-visit evaluation.
Dark-sky conservation	Sky brightness; number and type of intrusive light sources; shielded-lighting adoption; compliance with lighting guidelines; visitor awareness of dark-sky protection.	Sky-quality monitoring, lighting audit and visitor/stakeholder survey.

Table 3: Proposed Indicators for Astrotourism Readiness, Sustainability, Community Benefits and Dark-Sky Conservation

DISCUSSION

Beyond the Dark-Sky Paradigm: Heritage and Knowledge-Based Astrotourism

One of the principal conceptual implications of this study is that astrotourism resources should be understood more broadly than dark skies. Existing literature appropriately emphasises night-sky quality because low levels

of light pollution are essential for high-quality observation (Kanianska et al., 2020; Escario-Sierra et al., 2022). This resource-based perspective explains why remote landscapes and protected dark-sky environments have become central to many astrotourism destinations. Nevertheless, astronomical tourism can also derive value from cultural and scientific heritage. Historic observatories, instruments, scholarly traditions and narratives of astronomical knowledge may themselves constitute tourism resources when they are effectively interpreted. This suggests two broad but overlapping destination pathways. Dark-sky astrotourism is primarily resource-based, with darkness and celestial visibility constituting the principal attraction, whereas heritage-based astrotourism is more strongly interpretation-based, with historical sites, scientific achievements and knowledge traditions forming a central component of the experience. The distinction is analytical rather than absolute, but it broadens astrotourism beyond destinations whose competitiveness depends primarily on exceptional night-sky darkness.

The importance of interpretation also connects heritage-based astrotourism with knowledge tourism. Cooper et al. (2026) demonstrate that engagement with scientific knowledge can form an integral component of tourism without turning the experience into formal education. In this context, the tourism experience becomes richer when observation is accompanied by opportunities to understand the scientific, historical and cultural meanings of what is being observed. This is particularly significant for Islamic astronomy because visitors can encounter scientific achievement through specific places, instruments and human stories rather than as an abstract historical narrative. In Uzbekistan, Ulugh Beg can therefore be interpreted not simply as a ruler associated with an ancient monument but as part of a scientific environment in which observation, mathematical astronomy and instrumentation were interconnected. The Samarkand Observatory becomes valuable not only as an object to be visited but as a gateway through which visitors can engage with the intellectual history of Islamic civilisation.

This conceptualisation extends the conventional astrotourism proposition in two ways. First, it separates the existence of an astronomical resource from the production of tourism value: a dark sky, observatory or historic instrument becomes meaningful to tourists only through the experiences and interpretations constructed around it. Second, it gives destinations with major astronomical heritage a route into astrotourism even when they are not positioned primarily as world-class dark-sky locations. The contribution of the Uzbekistan case is therefore not to displace the importance of environmental quality but to show how heritage and knowledge can complement observational resources. Heritage-based astrotourism can consequently be understood as a form of knowledge-rich experiential tourism in which the contemporary sky and the historical development of astronomy are brought into the same visitor narrative.

Civilisational Differentiation and Ecosystem Development

The second major implication concerns destination differentiation. If astrotourism destinations offer essentially identical experiences such as telescope observation, stargazing, astrophotography and camping, competitive differentiation becomes difficult. Destination identity therefore depends upon integrating astronomical experiences with resources and narratives that cannot easily be replicated elsewhere. Malaysia can differentiate its offering through tropical environments, Islamic falak traditions and contemporary astronomy experiences. Uzbekistan possesses an especially strong heritage-based differentiator through the convergence of Ulugh Beg, Samarkand, Islamic astronomy and the Silk Road. This combination is rooted in place and history, giving it a degree of authenticity that generic stargazing products cannot easily reproduce. Civilisational identity thus becomes an economic and interpretive asset when it shapes the design of tourism experiences rather than functioning merely as background information.

Distinctive positioning, however, cannot be sustained by narrative alone. The Malaysian experience suggests that astrotourism should not be developed as an isolated tourism product because its viability depends upon coordination among environmental management, infrastructure, interpretation, tourism operators, educational institutions, communities and digital systems. This is consistent with Escario-Sierra et al. (2022), who emphasise institutional and social interaction within sustainable astrotourism development. For Uzbekistan, the implication is that the Ulugh Beg Observatory should not be treated simply as a standalone heritage attraction. It can instead function as an anchor within a wider ecosystem involving museums, universities, astronomy education, trained guides, tourism businesses, local communities and night-sky experiences. Such an

ecosystem converts heritage significance into a network of complementary products, services and learning opportunities.

The relationship between differentiation and ecosystem development is central to the adaptation argument of this article. Uzbekistan's competitive strength lies in heritage that is historically specific, while Malaysia's principal contribution is experience in identifying the wider conditions required for astrotourism development. These two elements are complementary rather than equivalent. The Uzbek context does not require replication of Malaysian products; it requires adaptation of the mechanisms through which resources are interpreted, connected to stakeholders and transformed into visitor experiences. This explains why the proposed framework gives equal attention to heritage narratives, education, digital interpretation, community participation and destination networking. Mainstreaming astrotourism is ultimately not a matter of adding stargazing to an existing destination, but of building a coherent system in which astronomical resources, civilisational identity and tourism delivery reinforce one another.

PILOT APPLICATION: SAMARKAND ASTRO-HERITAGE EXPERIENCE

Samarkand is proposed as the most appropriate pilot destination because the Ulugh Beg Observatory provides the clearest point at which Uzbekistan's astronomical heritage can be connected with contemporary astrotourism. The pilot is conceived as a limited, testable destination prototype rather than a national roll-out. Its core visitor journey would begin with daytime interpretation at the Ulugh Beg Observatory, including explanation of the monumental meridian instrument, historical observation methods and the scientific environment of fifteenth-century Samarkand. This would be followed by a guided heritage-and-knowledge component linking astronomy to the wider intellectual history of the city and, where site and sky conditions permit, an evening observation session that connects the historical narrative with the contemporary night sky.

The Malaysian lessons would be adapted at the level of delivery mechanisms: structured astronomy interpretation, trained guides, stakeholder coordination, digital information, community-linked services and attention to dark-sky quality. They would not be transferred as identical tourism products. Before implementation, the pilot should undertake a baseline assessment using the indicators in Table 3, including night-sky quality, night-time accessibility and safety, visitor-service capacity, community participation opportunities, heritage conservation requirements and institutional responsibilities. A small-scale trial could then collect primary data from four stakeholder groups identified as essential for empirical validation: tourists, destination managers and guides, local communities and businesses, and relevant government or heritage authorities. Tourist measures should include awareness, satisfaction, learning outcomes and willingness to participate in astronomy-related experiences; stakeholder interviews should examine operational feasibility, governance, conservation concerns and expected community benefits.

The pilot would provide a practical test of the adaptation framework by determining whether a heritage-led astronomy experience can increase interpretive value and visitor engagement without compromising heritage integrity or night-sky resources. Evidence from the pilot could then be used to refine indicators, establish locally appropriate thresholds and determine whether the model should be extended to other Uzbek destinations. In this way, Samarkand functions not merely as an illustrative case but as the proposed empirical bridge between the conceptual framework developed in this study and a future stakeholder-validated astrotourism strategy.

STRATEGIC IMPLICATIONS: POSITIONING UZBEKISTAN AS A GLOBAL ISLAMIC ASTRONOMY HERITAGE DESTINATION

The preceding analysis suggests that Uzbekistan does not need to compete directly with internationally established dark-sky destinations on the basis of darkness alone. Such a strategy would underuse the destination's most distinctive resource, namely the authenticity and historical depth of its Islamic astronomical heritage. The strategic opportunity is instead to combine contemporary astronomical experience with a place-based narrative of scientific achievement centred on Samarkand. This positioning follows directly from the distinction developed in this article between resource-based dark-sky astrotourism and interpretation-based heritage astrotourism. It also aligns with Uzbekistan's established Silk Road identity by adding science and

knowledge to the destination's cultural and historical appeal. On this basis, the article proposes positioning Uzbekistan as a Global Islamic Astronomy Heritage Destination.

Such positioning could be operationalised through four interconnected product clusters rather than through a single flagship attraction. Observatory Heritage Tourism could position the Ulugh Beg Observatory as an anchor for experiences explaining astronomical instruments, historical observation and the scientific environment of fifteenth-century Samarkand. An Islamic Astronomy Heritage Trail could connect astronomy-related sites and narratives with the wider heritage of science, scholarship and civilisation, enabling visitors to encounter astronomy within a broader cultural itinerary. Islamic Science Tourism could provide structured knowledge-oriented experiences for students, universities, specialist groups and culturally motivated tourists. Night-Sky Experiential Tourism could then connect this historical knowledge with contemporary observation. The strategic value of these clusters lies in their complementarity: each addresses a different dimension of the visitor experience, but together they reinforce a coherent destination identity based on astronomy, heritage and knowledge.

The combination of observatory heritage and night-sky experience is particularly significant. A visitor could spend the day learning how astronomers in fifteenth-century Samarkand measured the heavens and later participate in observation of the contemporary night sky. Such an experience would allow visitors to move beyond simply encountering a historic place by understanding its heritage, engaging with the stories associated with it, learning about the scientific knowledge developed there, and finally connecting this historical understanding with direct observation of the night sky. This creates a more meaningful and distinctive tourism experience than conventional stargazing alone.

Uzbekistan's strategic advantage is consequently not simply that tourists can observe stars there. Stars can be observed in many destinations. Its distinctive advantage lies in its ability to explain who observed those stars centuries earlier, how they observed them, what knowledge they produced and why that knowledge mattered to the development of astronomy. Malaysia's experience contributes to this proposition by demonstrating the importance of developing the surrounding ecosystem, including tourism products, educational interpretation, community participation, infrastructure, environmental awareness and stakeholder collaboration. The positioning proposed here therefore depends on coordination between heritage conservation and tourism development rather than on branding alone. If the historical narrative, contemporary astronomical experience and supporting visitor ecosystem are developed together, the destination can offer an experience that is both place-specific and difficult for competing destinations to replicate.

CONCLUSION

Astrotourism is increasingly moving beyond its early characterisation as a narrowly defined niche based on stargazing. Its intersections with sustainable tourism, science tourism, education and cultural heritage create opportunities for destinations to construct experiences that are simultaneously observational, interpretive and knowledge-based. This article extends that perspective by distinguishing between astrotourism that derives its primary value from dark-sky resources and heritage-based astrotourism in which historical sites, scientific instruments, knowledge traditions and civilisational narratives form a substantive part of the visitor experience. The distinction does not separate the two forms absolutely; rather, it shows how heritage can complement contemporary observation and broaden the resource base of astrotourism.

Malaysia and Uzbekistan illustrate different but complementary dimensions of this development. Malaysia represents an emerging astrotourism context in which natural environments, astronomical education, Islamic astronomical narratives and tourism development are increasingly interconnected, while its experience also reveals challenges involving light pollution, accessibility, infrastructure, awareness and stakeholder coordination. Uzbekistan possesses a different comparative advantage in the historical depth and authenticity of its astronomical heritage, particularly the legacy of Ulugh Beg and the Samarkand Observatory. The analysis therefore supports the use of Malaysian experience as a developmental reference rather than a replicable model. Observatory-based tourism, astronomy education, digital interpretation, community participation and destination networking are transferable as principles, but their application must be reconstructed around Uzbekistan's distinctive heritage and Silk Road tourism environment.

The proposed Malaysia-Uzbekistan Astrotourism Adaptation Framework translates this argument into seven dimensions of destination development, while the six-dimensional comparative matrix clarifies the environmental, socioeconomic, cultural, infrastructural, technological and governance conditions affecting adaptation. The proposed indicator set further operationalises readiness, sustainability, community benefits and dark-sky conservation, and the Samarkand pilot demonstrates how these elements can be assembled into a testable destination prototype. The framework remains strategic rather than empirically validated in Uzbekistan

because no new primary data were collected in the present document-based study. This limitation defines the next research stage: primary data should be collected from tourists, destination managers and guides, local communities and businesses, and government or heritage stakeholders during the proposed pilot. Such evidence would permit validation of the indicators, establishment of local thresholds and assessment of operational feasibility, community value, conservation effects and market response.

Ultimately, Uzbekistan's opportunity extends beyond inviting tourists to look at the stars. Its distinctive potential lies in enabling visitors to understand how those same stars were observed, measured and interpreted in one of the major scientific centres of Islamic civilisation, and then to connect that historical understanding with the contemporary sky. Through the integration of astronomy, heritage, science, education and Silk Road tourism, Uzbekistan can develop a tourism proposition rooted in its own civilisational identity rather than in the replication of established dark-sky models. This provides the strategic basis for positioning the country as a Global Islamic Astronomy Heritage Destination.

ACKNOWLEDGMENT

This research was supported by the Sheikh Abdullah Fahim Chair Grant, Institute of Islam Hadhari, Universiti Kebangsaan Malaysia (RH2024-003), through the project “Kajian Kebolehlaksanaan Aplikasi Pelancongan Astronomi dalam Kalangan Pelancong di Malaysia”, and the Universiti Kebangsaan Malaysia Translational Research Grant (UKM-TR2023-05), through the project “Pemeriksaan Astrotourism sebagai Produk Arus Perdana Industri Pelancongan”.

DECLARATIONS

Ethical Approval: Not applicable. This study is based exclusively on document analysis and did not involve human participants or animals.

Conflict of Interest: The author declares no conflict of interest.

Data Availability: No new dataset was generated for this study. The analysis is based on published literature and publicly available documentary sources.

REFERENCES

1. Ahmad, R., Khairul Izam, R. A.-A., Ahmad, S., & Rosley, M. S. F. (2026). Community-driven conservation of Pantai Kelanang's dark skies for sustainable astro-tourism. *Malaysian Journal of Sustainable Environment*, 13(1), 291-312. <https://doi.org/10.24191/37t9n151>
2. Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27-40. <https://doi.org/10.3316/QRJ0902027>
3. Cooper, E., Hutton, E., & Varnajot, A. (2026). A science tourism spectrum: Towards conceptual clarity around knowledge-based products in tourism. *Current Issues in Tourism*. Advance online publication. <https://doi.org/10.1080/13683500.2026.2636765>
4. Dimyati, M. S., & Safiai, M. H. (2024). Tinjauan aspek pelancongan astronomi di Kompleks Falak Al-Khawarizmi dalam meningkatkan penajaan aktiviti ekonomi setempat. *BITARA International Journal of Civilizational Studies and Human Sciences*, 7(3), 1-12.
5. Escario-Sierra, F., Álvarez-Alonso, C., Moseñe-Fierro, J. A., & Sanagustín-Fons, M. V. (2022). Sustainable tourism, social and institutional innovation-The paradox of dark sky in astrotourism. *Sustainability*, 14(11), 6419. <https://doi.org/10.3390/su14116419>

6. Faid, M. S., Mohd Nawawi, M. S. A., Norman, M. P., Masbah, D. I., Mohd Saadon, M. H., & Nizam, N. K. (2022). The capability of astrotourism on preserving sustainability: A case study in Malaysia. *Journal of Contemporary Islamic Studies*, 8(3). <https://doi.org/10.24191/jcis.v8i3.11>
7. Fayos-Solá, E., Marín, C., & Jafari, J. (2014). Astroturismo: No hay réquiem por un turismo significativo. *PASOS: Revista de Turismo y Patrimonio Cultural*, 12(3), 663-671. <https://doi.org/10.25145/j.pasos.2014.12.048>
8. Hanafiah, M. H., Rozali, E. A., Sidik @ Mat Sidek, R., Md Sham, F., & Ahmat Murtza, M. H. (2025). Bridging interest and potential of astrotourism in Malaysia: Barriers, opportunities, and strategies. *Planning Malaysia*, 23(38), 809-824. <https://doi.org/10.21837/pm.v23i38.1828>
9. Kanianska, R., Škvareninová, J., & Kaniansky, S. (2020). Landscape potential and light pollution as key factors for astrotourism development: A case study of a Slovak upland region. *Land*, 9(10), 374. <https://doi.org/10.3390/land9100374>
10. Ruggles, C., & Cotte, M. (Eds.). (2010). *Heritage sites of astronomy and archaeoastronomy in the context of the UNESCO World Heritage Convention: A thematic study*. ICOMOS and International Astronomical Union.
11. Safiai, M. H., Ab Rahman, M. F., Abul Hassan Ashari, M. Z., Jamsari, E. A., & Muhd Adnan, N. I. (2020). The feasibility of Islamic astrotourism in Malaysia. *International Journal of Advanced Research*, 8(11), 162-166. <https://doi.org/10.21474/IJAR01/11988>
12. Soleimani, S., Bruwer, J., Gross, M. J., & Lee, R. (2019). Astro-tourism conceptualisation as special-interest tourism (SIT) field: A phenomenological approach. *Current Issues in Tourism*, 22(18), 2299-2314. <https://doi.org/10.1080/13683500.2018.1444021>
13. Zotti, G., & Mozaffari, S. M. (2020). New light on the main instrument of the Samarqand Observatory. *Journal for the History of Astronomy*, 51(3), 255-271. <https://doi.org/10.1177/0021828620943986>