

SUSTAINABLE TOURISM FLOW ECONOMY AND GOVERNMENT GOVERNANCE OF CULTURAL HERITAGE SITES WITHIN THE CIRCULAR BIOECONOMY FRAMEWORK LESSONS FROM THE MOGAO CAVES OF DUNHUANG AND IMPLICATIONS FOR SAMARKAND

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Abstract

The article explored sustainable visitor flow governance at cultural heritage sites by adapting circular bioeconomy principles. A comparative case study examined the Mogao Caves in Dunhuang and Samarkand through document analysis, literature review, field observations and informal interviews. Four mechanisms were organised: reducing heritage pressures, digital substitution, community benefit circulation and institutional coordination. Recommendations for Samarkand addressed carrying capacity assessment, electronic reservations, digitisation and preventive monitoring. Mahalla participation and interagency cooperation were highlighted. Implementation was structured into short, medium and long term phases. Findings remained qualitative, and subsequent observation and quantitative evaluation were identified as necessary for assessing the effectiveness of the proposals.

Keywords: sustainable tourism, visitor flows, cultural heritage, circular bioeconomy, digital substitution, mahalla participation, preventive monitoring, Samarkand, Mogao Caves.

Annotatsiya

Maqolada madaniy meros obyektlarida turistik oqimlarni barqaror boshqarish imkoniyatlari sirkulyar bioiqtisodiyot tamoyillarini moslashtirish orqali o'rganildi. Dunxuandagi Mogao g'orlari va Samarqand tajribasi qiyosiy tahlil qilindi. Tadqiqotda hujjatlar va ilmiy adabiyotlar tahlili, dala kuzatuvlari hamda norasmiy suhbatlardan foydalanildi. Merosga tushadigan yukni kamaytirish, raqamli muqobillar, manfaatlarni mahalliy jamoalarda taqsimlash va institutsional muvofiqlashtirishdan iborat to'rtta mexanizm tizimlashtirildi. Samarqand uchun tashrif sig'imini baholash, elektron bronlash, raqamlashtirish va preventiv monitoring yo'nalishlari taklif etildi. Mahallalar ishtiroki hamda idoralararo hamkorlikning ahamiyati yoritildi. Qisqa, o'rta va uzoq muddatli amalga oshirish bosqichlari belgilandi. Xulosalar sifat tadqiqoti doirasida shakllantirilib, takliflarning natijadorligini keyingi kuzatuvlar va miqdoriy baholash orqali tekshirish zarurati alohida qayd etildi.

Kalit soʻzlar: barqaror turizm, turistik oqimlar, madaniy meros, sirkulyar bioiqtisodiyot, raqamli muqobillar, mahalla ishtiroki, preventiv monitoring, Samarqand, Mogao gʻorlari.

Аннотация

В статье были изучены возможности устойчивого управления туристическими потоками на объектах культурного наследия посредством адаптации принципов циркулярной биоэкономики. Сопоставлялся опыт пещер Могао в Дуньхуане и Самарканда. Использовались анализ документов и научной литературы, полевые наблюдения и неформальные интервью. Были систематизированы четыре механизма: снижение нагрузки на наследие, цифровое замещение, распределение выгод среди местных сообществ и институциональная координация. Для Самарканда были предложены оценка допустимой посещаемости, электронное бронирование, цифровизация и превентивный мониторинг. Рассматривалось значение участия махаллей и межведомственного сотрудничества. Были определены краткосрочные, среднесрочные и долгосрочные этапы реализации. Выводы были сформулированы в рамках качественного исследования; необходимость последующей проверки результативности предложений посредством дальнейших наблюдений и количественной оценки была отдельно отмечена.

Ключевые слова: устойчивый туризм, туристические потоки, культурное наследие, циркулярная биоэкономика, цифровое замещение, участие махаллей, превентивный мониторинг, Самарканд, пещеры Могао.

INTRODUCTION

Walking through Registan Square on a Friday afternoon in spring 2025, I counted more than forty tour buses parked along the perimeter, their groups funneling through the narrow archways of the three madrasahs. Inside, visitors pressed close to the tilework, guides raised their voices above one another, and the air felt thick with humidity and breath. A UNESCO report released the same year would later confirm what my eyes could see: overcrowding during peak seasons is accelerating the degradation of Samarkand's heritage fabric [17]. Yet unlike Dunhuang, where a decade-old appointment system caps daily visitation at 6,000 [5], Samarkand has no comparable mechanism in place. Tickets are bought on-site, entry is first-come-first-served, and the carrying capacity of individual monuments has never been formally assessed.

This gap is not unique to Samarkand. Across the Silk Road, heritage cities are grappling with what might be called the "flow paradox": the same social media attention that brings visitors and revenue also brings congestion, degradation, and community resentment [13]. Cities like Zibo and Harbin have shown that viral fame can arrive overnight-and vanish just as quickly [2]. For cultural heritage sites, however, the stakes are higher. A mural damaged by excess humidity cannot be restored by the next marketing campaign. The question, then, is not whether to manage tourism flows, but how-and at what scale, through what institutions, and with what distribution of benefits.

The circular bioeconomy offers a useful lens for thinking through this problem. Originally developed for agricultural and industrial systems, its core principles—reduce, reuse, recycle, substitute, and govern—translate surprisingly well [1]; [4] to heritage tourism when one treats the heritage body itself as a finite, non-renewable resource. A physical visit "consumes" a unit of that resource; digital display can substitute for some consumption; community participation circulates the benefits; and government governance provides the institutional scaffolding that makes the other three mechanisms work. This paper develops that translation systematically, using Dunhuang as a proven model and Samarkand as a site of urgent adaptation.

The choice of these two cases is not arbitrary. Both are Silk Road World Heritage sites with comparable visitor pressures, yet their governance trajectories diverge sharply. Dunhuang's Academy, established in 1944 [5], has built a vertically integrated system spanning conservation, research, and visitor management. Samarkand, by contrast, operates under a fragmented multi-sectoral arrangement in which culture, tourism, and urban planning often pull in different directions. This "difference within similarity"—to borrow from the most-similar-systems-design tradition—makes the comparison analytically productive.

As a doctoral candidate based in Samarkand for a full academic year, I had the opportunity to conduct informal interviews with heritage officials, tour guides, and mahalla residents, and to observe visitor patterns across seasons. These field observations inform the analysis throughout, particularly in the sections on Samarkand's current challenges and the feasibility of proposed adaptations. The paper is also a phased outcome of a National Social Science Fund project on tourism flow economy in the all-media era, and focuses on the project's third plateau: sustainable development mechanisms and government governance models.

Four questions guide the inquiry. First, what makes tourism flows at heritage sites different from those at ordinary destinations, and what does this imply for governance? Second, how can the circular bioeconomy's vocabulary be operationalized for heritage tourism without stretching the analogy beyond its useful limits? Third, what specifically did Dunhuang do right—and which elements of its model are genuinely transferable versus context-dependent? Fourth, what would a realistic adaptation pathway look like for Samarkand, given its institutional constraints, community structure, and heritage geography? The paper proceeds by reviewing relevant literature, outlining the research design, analyzing the Dunhuang case, diagnosing Samarkand's situation, proposing mechanism-specific adaptations, and concluding with policy recommendations and a phased roadmap.

LITERATURE REVIEW

Tourism Flow Economy and Government Governance

The concept of "flow economy" was first articulated by Chinese scholars Zhou and Han in 2002 [19], who described it as a regional development model in which external resources—capital, talent, information—are attracted, reorganized, and integrated to generate economic energy that radiates outward. Their framework was developed in the context of urban and regional economics, well before social media transformed

how tourism destinations gain attention. What the all-media era has added is speed and volatility: a destination can go from obscurity to millions of visitors in weeks, driven not by deliberate marketing but by a single viral video or influencer post. Collins's [3] interaction ritual chain theory helps explain why this happens-collective emotion, shared symbols, and rhythmic interaction create moments of "emotional energy" that participants want to reproduce, and tourism has become one of the primary arenas in which these rituals play out.

Yet the literature on tourism flow economy remains uneven in several respects. Monetization has received the most attention: Xie et al. [18] analyzed how e-commerce live streaming creates value for destinations, while Hu [11] identified platform aggregation, innovative attraction, and mechanism-based management as the three key levers for sustaining flow-driven growth. Government governance, by contrast, has been studied largely through the lens of crisis response-Chen et al. [2] documented how "internet-famous cities" managed sudden influxes, and Nunkoo [14] emphasized the role of trust, power, and social capital in sustainable destination governance. What is missing, in my view, is a middle layer: not just how governments respond to crises, but how they build routine, preventive systems that manage flows before they become crises. This gap is particularly acute for cultural heritage sites, where the cost of a crisis-mural degradation, structural damage-is irreversible. The present study attempts to occupy that middle layer.

Circular Bioeconomy and Its Applicability to Heritage Tourism

The circular bioeconomy has emerged over the past decade as a policy framework that combines the resource-efficiency logic of circular economy with the renewable-resource focus of bioeconomy. The European Commission's 2018 strategy and its 2025 update frame it as a way to maximize the value of biological resources by keeping them in use longer and minimizing waste [1]; [6]; [7]. Its core principles-resource reduction, circular reuse, recycling, renewable substitution, and systemic governance [4]-were designed for agricultural and industrial systems. The question is whether they travel well to cultural heritage tourism.

I would argue that they do, but only with a deliberate act of translation. The key move is to treat the heritage body itself-the murals, the architecture, the archaeological deposits-as a finite, non-renewable resource [8]. A physical visit "consumes" a small unit of that resource through foot traffic, humidity, carbon dioxide, and wear. Once consumed, that unit cannot be recovered. From this starting point, the circular bioeconomy's principles map onto heritage governance in the following way. Resource reduction becomes appointment-based visitor caps and carrying capacity management-limiting how much of the resource is consumed in a given period. Digital substitution becomes the use of digital replicas, virtual tours, and immersive exhibitions-ininitely replicable at near-zero marginal cost-to satisfy some of the demand that would otherwise be met through physical visitation [10]. Social circulation becomes the participation of local communities in tourism benefits-ensuring that the economic energy generated by heritage flows circulates within the community rather than leaking out to external operators. Governance assurance becomes the institutional

infrastructure-preventive monitoring, regulatory frameworks, multi-sectoral coordination-that makes the other three mechanisms function reliably.

This translation is not without risks. One could accuse it of stretching the bioeconomy metaphor beyond its useful limits, particularly since heritage is not "biological" in any literal sense. But I would counter that the value of the framework lies not in biological literalism but in its systematic attention to resource flows, substitution possibilities, and governance infrastructure-precisely the dimensions that heritage tourism management often treats in isolation. The systematic application of this framework to heritage tourism remains, to my knowledge, a gap in the existing literature.

Research Gaps and Analytical Framework

Three gaps structure the present inquiry. First, tourism flow economy research has been oriented primarily toward ordinary destinations and viral phenomena, with relatively little theoretical construction specifically for cultural heritage scenarios, where the resource being "consumed" is irreplaceable. Second, circular bioeconomy research has concentrated on agriculture, forestry, and industrial biotechnology; its application to heritage tourism, if it exists at all, remains fragmentary. Third, Dunhuang-Samarkand comparative studies-where they exist-tend to stay at the level of experience introduction rather than mechanism extraction and adaptive design.

The analytical framework developed here takes the circular bioeconomy as its theoretical perspective, organizes the analysis around four mechanism dimensions-resource reduction, digital substitution, social circulation, and governance assurance-treats Dunhuang as the primary experience source, and tests the framework's applicability through Samarkand as the adaptation object (Figure 1). The framework is not intended as a universal model but as a diagnostic tool: it helps identify which mechanisms are present, which are missing, and what institutional conditions would be needed to activate them.

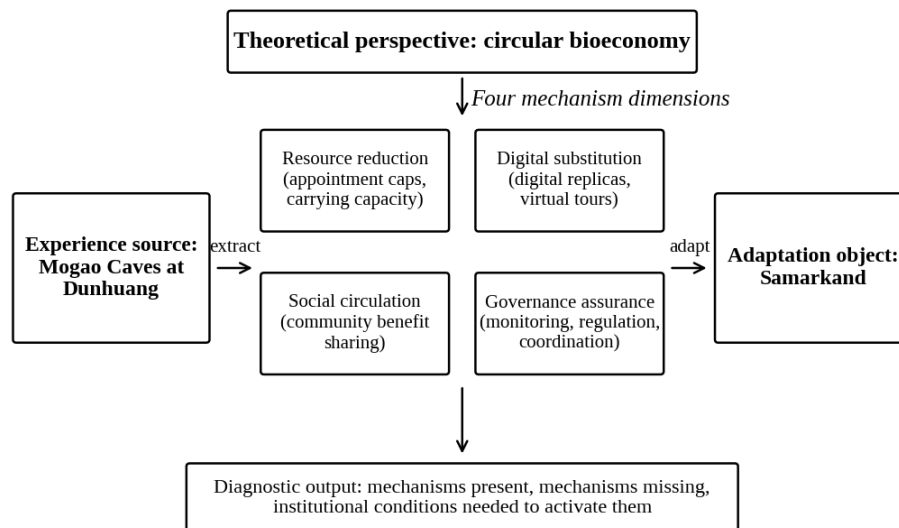


Figure 1. Analytical framework of the study¹

¹ Source: developed by the author based on the framework described in the text.

Figure 1 shows how the study is organized. The circular bioeconomy serves as the theoretical perspective from which four mechanism dimensions are derived: resource reduction, digital substitution, social circulation, and governance assurance. The Mogao Caves at Dunhuang act as the experience source from which working practices under each dimension are extracted, while Samarkand is the adaptation object to which these practices are tested and adjusted. The output of the framework is diagnostic rather than prescriptive: it shows which mechanisms are already present, which are missing, and which institutional conditions are needed to activate them.

METHODOLOGY

This paper adopts the comparative case study method, policy text analysis, and literature analysis. The comparative case study follows the "Most Similar Systems Design" logic: both cases are Silk Road World Cultural Heritage sites facing tourism growth and heritage protection pressures, but differ in governance models, institutional environments, and technology applications-this "difference within similarity" provides analytical space for causal inference. Data sources include UNESCO state of conservation reports (2024, 2025) [16]; [17], Dunhuang Academy monitoring reports [5], Uzbekistan State Committee for Tourism data, policy documents, and field observation materials.

Table 1

Comparative Framework of the Mogao Caves at Dunhuang and Samarkand¹

Dimension	Mogao Caves Dunhuang	Samarkand
Heritage type	Buddhist grotto site, inscribed 1987	Central Asian ancient city, inscribed 2001
Management system	Dunhuang Academy, unified protection-research-promotion	Multi-sectoral decentralized, no unified heritage agency
Visitor scale (2024)	2 million, steady growth	2.6 million foreign visitors, rapid growth
Appointment system	Online since 2014, daily cap 6,000	No unified platform, mainly on-site tickets
Digitalization	300 caves acquired, digital center serves 6,000/day	Initial stage, no systematic acquisition
Monitoring	Provincial platform covering 6 grotto sites	No systematic preventive monitoring
Community participation	"Mogao Academy" brand, 22 study bases	Hunarmand Association (3,000+), limited decision participation

The analysis was carried out in three steps. First, documents and published data on both sites were coded along the four mechanism dimensions of the analytical framework, so that each practice or gap could be assigned to resource reduction, digital substitution, social circulation, or governance assurance. Second, the two cases were compared dimension by dimension to separate elements of the Dunhuang model that

¹ Source: compiled by the author based on Demas et al. (2015), UNESCO World Heritage Centre (2024, 2025) and field observations.

depend on its specific context, such as a single concentrated cave precinct and a long-established managing academy, from principles that can be transferred. Third, the transferable principles were checked against Samarkand's institutional setting, heritage geography, and existing studies of its tourism development [15], as well as against field observations and informal interviews with heritage officials, tour guides, and mahalla residents. The main features of the two cases used in the comparison are summarized in Table 1.

Table 1 shows that the two sites share key similarities: both are Silk Road World Heritage properties and both receive visitor flows of a comparable order, about 2 million visitors at the Mogao Caves and about 2.6 million foreign visitors in Samarkand in 2024. The differences lie in governance and tools. Dunhuang has a unified managing body, an online appointment system with a daily cap of 6,000 visitors since 2014, 300 digitally acquired caves, and a provincial monitoring platform covering six grotto sites. Samarkand, in contrast, has a multi-sectoral management arrangement, mainly on-site ticket sales, an initial stage of digitization, and no systematic preventive monitoring, while community participation relies on the Hunarmand Association with more than 3,000 members. This combination of similar pressures and different institutional responses is what makes the comparison useful.

ANALYSIS AND RESULTS

1 The Dunhuang Experience: Four Mechanisms under the Circular Bioeconomy

1.1 Resource Reduction: Total Volume Control and Appointment-Based Caps

The turning point came around 2000, when visitor numbers began climbing steeply and conservators noticed that cave micro-environments-temperature, humidity, carbon dioxide-were spiking beyond safe thresholds during peak hours. The response was not immediate; it took more than a decade of internal debate, technical experimentation, and institutional coordination before the current system took shape. When the Mogao Caves Digital Exhibition Center opened in 2014, it introduced a model that was novel for Chinese museums at the time: "total volume control, online appointment, digital display, cave visitation." The daily cap was set at 6,000 visitors-a figure derived from conservation science, not from marketing targets or revenue projections [5].

What makes the system work in practice is less the cap itself than the infrastructure behind it. The Tourism Opening Scheduling Command Center pulls together real-time appointment data, turnstile counts at the entrance, and in-cave visitor tracking, cross-referencing each against heritage protection thresholds. During peak season, the system draws on historical patterns plus real-time weather and traffic data to anticipate congestion, then pushes personalized off-peak suggestions through the official mini-program. The result is a closed loop: prediction feeds into planning, planning into guidance, and guidance back into measured outcomes. Peak-off-peak differential pricing adds a market signal on top of the informational one, nudging price-sensitive visitors toward quieter periods. From a circular bioeconomy perspective, this is the "reduction" principle made operational: the consumption of a finite, non-

renewable resource is bounded by scientifically determined limits, not by demand alone.

1.2 Digital Substitution: Digital Interpretation and Online Experience

If appointment caps limit how much heritage is consumed, digital substitution expands what can be experienced without consuming it at all. The numbers are striking. By the end of 2024, the Dunhuang Academy had completed high-precision acquisition of 300 caves and 28,100 square meters of murals, produced 196 panoramic tours, and 3D-scanned 212 caves. The "Digital Dunhuang" resource library has logged over 23 million visits from users in 78 countries [9]. What these figures do not fully capture is the substitution effect: the digital exhibition center's second phase, with its 8K dome screens, serves another 6,000 visitors daily-people who would otherwise be adding foot traffic and humidity inside the caves. Academy staff estimate that body reception pressure has dropped by roughly 30% as a result.

The online ecosystem extends the substitution further. The "Cloud Tour Dunhuang" mini-program, the "Digital Library Cave" interactive experience, and various VR exhibitions allow remote users to engage with the heritage at near-zero marginal cost [10]. From the circular bioeconomy standpoint, digital resources function as "renewable substitutes": infinitely replicable, non-depleting, and capable of satisfying demand that would otherwise be met through physical visitation. The carbon footprint argument is secondary but real-every visitor who experiences Dunhuang digitally rather than by flying to Gansu represents avoided emissions. What matters most for heritage governance, though, is that digital substitution decouples access from physical impact, allowing the site to serve a global audience while protecting the caves themselves.

1.3 Social Circulation: Community Participation and Living Heritage

The Dunhuang Academy created the "Mogao Academy" study tour brand, and Dunhuang City has launched 22 types of study tour products with 22 bases. Through the "cultural tourism + all industries" strategy, local residents share tourism benefits by participating in interpretation, homestays, handicrafts, and catering. In 2025, Dunhuang ranked among China's top 100 counties for comprehensive tourism strength. When residents perceive the alignment between heritage protection and their own interests, they transform from "potential threats" to "heritage guardians," forming a virtuous cycle of "protection-benefit-more active protection." This embodies the "reuse" and "recycling" principles-social capital is activated and circulated into an endogenous driving force for heritage protection.

1.4 Governance Assurance: Preventive Monitoring and Proactive Intervention

The Dunhuang Academy established the Gansu Provincial Grotto Temple Monitoring and Early Warning Platform, deploying temperature/humidity sensors and CO₂ monitors inside caves for real-time micro-environment monitoring. When data exceeds thresholds, the system automatically issues warnings. The platform links with the meteorological bureau, suspending cave openings during extreme weather such as sandstorms. Currently covering six grotto temple sites, the platform achieves real-time aggregation through IoT and wireless sensor technologies. Institutionally, the 2002

"Regulations on the Protection of the Mogao Caves at Dunhuang" provides a special legal basis [5], and the Dunhuang Academy as a unified management agency coordinates cultural relic protection, tourism management, and local government. This system shifts protection from "mending the fold after the sheep is lost" to "preparing for rain before it falls," providing a stable institutional environment for the other three mechanisms.

1.5 Special Logic of Tourism Flow Monetization at Heritage Sites

Tourism flow monetization at cultural heritage sites differs from ordinary internet-famous cities in four aspects: (1) high ticket dependence with a short monetization chain, limiting price regulation room; (2) heritage protection constraints restrict commercial development space and visitor consumption behavior; (3) digital products become a new growth point-high-precision digital assets can achieve value transformation through authorized use, virtual experiences, and cultural creative products at near-zero marginal cost, without increasing heritage carrying pressure; (4) community participation is the key increment for extending the monetization chain-guiding visitor flows to community consumption links through study tours, homestays, and handicraft displays extends the chain and shares benefits [18]. Heritage sites must break through ticket dependence through digital value addition and community chain extension under protection constraints.

2 Samarkand: Current Situation and Challenges

Samarkand's trajectory is, in some ways, a mirror image of Dunhuang's-except that the growth curve has been steeper and the institutional response slower. The city has over 2,750 years of continuous urban history and was inscribed as a World Heritage site in 2001 [17]. International visitor numbers climbed from roughly 180,000 in 2015 to approximately 2.6 million in 2024, with projections exceeding 3 million for 2025. Average length of stay has crept up from 2.6 days in 2024 to 3.5 days in 2025, suggesting that visitors are beginning to move beyond the standard day-tour itinerary. Samarkand International Airport handled 1.38 million passengers in 2024, a 37% year-on-year increase, and was recognized by Airports Council International as one of the fastest-growing airports in Europe and Central Asia [12].

These headline figures, however, obscure a set of structural problems that became visible during my fieldwork. Five challenges stand out.

First, heritage conservation pressures are mounting but largely unmeasured. UNESCO's 2025 state of conservation report [17] notes that core scenic areas experience severe overcrowding during peak seasons, and the heritage fabric faces accelerated degradation. What the report does not quantify-and what Samarkand currently lacks the infrastructure to quantify-is the relationship between visitor density and micro-environmental change inside enclosed monuments like Gur-e-Amir and Bibi-Khanym. During my visits, I observed that the air inside these domed structures becomes noticeably warm and humid when groups are present, yet no continuous monitoring system tracks these conditions.

Second, urban development and heritage protection are in tension. UNESCO's 2024 joint reactive monitoring mission [16] raised concerns about the "Third

Renaissance" renovation plan, which encompasses Registan Square, Shah-i-Zinda, Gur-e-Amir, and the Ulugbek Observatory. The mission warned that without prudent management and evidence-based assessment, these projects could have significant impacts on the heritage site. Of particular concern was the proposed site for a New Silk Road Museum near Bibi-Khanym Mosque-an area that falls within a traditional mahalla neighborhood and may conceal substantial underground archaeological deposits.

Third, community participation remains shallow despite existing institutional resources. The Hunarmand Craftsmen Association claims over 3,000 members and has organized multiple master classes for visitors, which is genuinely encouraging. But in conversations with residents in the old city, I heard a recurring theme: tourism revenue flows primarily to hotels, tour operators, and external businesses, while families who have lived in the mahallas for generations see little direct benefit [14]. Some core-area residents also face uncertainty about potential relocation as renovation projects advance. Decision-making about tourism development happens largely without community input.

Fourth, management capacity and professional expertise are stretched thin. UNESCO has repeatedly pointed to insufficient professional personnel and inadequate management systems, recommending a comprehensive national capacity-building plan covering World Heritage site management, heritage impact assessment, and technical conservation [16; 17]. In practice, the responsibility for Samarkand's heritage is dispersed across multiple agencies-culture, tourism, urban planning, local administration-with no single body empowered to coordinate across them.

Fifth, there is no unified appointment or monitoring system. Core attractions still operate primarily on walk-up ticket sales. There is no carrying capacity assessment for individual monuments, no real-time visitor tracking, and no preventive monitoring of micro-environmental conditions. In effect, Samarkand is managing a 2.6-million-visitor destination with the institutional tools of a much smaller one-a gap that will only widen as visitor numbers continue to grow.

3 Mechanism Adaptation and Pathway Design for Samarkand

3.1 Resource Reduction: Unified Appointment Platform and Carrying Capacity Management

Samarkand should unite core attractions and, with the State Committee for Tourism's coordination, build a unified electronic appointment platform. First, organize experts to conduct carrying capacity assessments for Registan Square, Gur-e-Amir, Bibi-Khanym, and Shah-i-Zinda, determining daily and instantaneous maximum capacities based on heritage protection thresholds [5; 8]. Second, implement time-slot appointments, tiered ticket prices, and off-peak prompts, using price leverage and information guidance to balance visitor distribution. Third, establish a real-time scheduling mechanism integrating ticket sales, entrance flows, and in-site visitor counts, with automatic warnings when flows approach capacity limits. Given Samarkand's more dispersed heritage layout, regulation plans must be more holistic and flexible than Dunhuang's centralized model.

3.2 Digital Substitution: Heritage Digitization and "Cloud Tour Samarkand"

Drawing on Dunhuang's technical experience, prioritize high-precision digital acquisition of core monuments with fragile conditions and high visitor pressure, establishing Samarkand heritage digital archives. Construct a digital exhibition center at the heritage area entrance, guiding visitors to first understand historical context through dome films and VR experiences before entering core areas, achieving orderly diversion and promoting transformation from "short-term sightseeing" to "in-depth experience." Launch a "Cloud Tour Samarkand" mini-program with panoramic tours, virtual guides, and AR interpretation, serving remote users and achieving "online + offline" dual-track experience [10].

3.3 Social Circulation: Mahalla Community Co-construction and Benefit Sharing

Samarkand's unique mahalla traditional community system is an important institutional resource. Support mahalla communities in developing family guesthouses, folk custom experiences, and intangible heritage projects, with government microloans and training. Deepen the Hunarmand Craftsmen Association's role by combining handicraft display with tourism experiences-"craftsman studio visits," "traditional craft workshops," and "intangible heritage shopping festivals." Establish a community tourism development fund, extracting a proportion of core attraction ticket revenue for community development and heritage maintenance, so residents directly feel the connection between protection and their interests [14]. Explore diverse business formats including handicrafts, song and dance, wellness, and ethnic cuisine to extend visitor stay time.

3.4 Governance Assurance: Preventive Monitoring and Multi-sectoral Coordination

Deploy temperature/humidity sensors, CO₂ monitors, and visitor flow counters inside key monuments (prioritizing enclosed spaces like Gur-e-Amir and Bibi-Khanym), building a real-time micro-environment monitoring platform linked with meteorological departments. Accelerate the establishment of a unified Samarkand heritage management agency coordinating culture, tourism, and urban planning functions, responsible for carrying capacity determination, appointment platform operation, monitoring, project approval, and community coordination. Promote the formulation of special regulations for Samarkand heritage protection, clarifying protection requirements and approval procedures. Formulate a comprehensive capacity building plan covering World Heritage management, heritage impact assessment, and tourism flow management.

4 Institutional Safeguards and Policy Recommendations

At the regulatory level, accelerate the establishment of a specialized heritage management agency and promote the formulation of the "Regulations on the Protection of the Samarkand World Heritage Site"; within the UNESCO framework, continue suspending large-scale new construction in heritage areas and buffer zones until new urban design guidelines receive positive reviews [16]. At the cooperation level, deepen technical exchanges with the Dunhuang Academy in digitalization, preventive monitoring, and tourism flow management; expand heritage protection cooperation

with Italy and other countries; actively participate in UNESCO capacity building programs.

The proposed measures are grouped into three implementation phases in Table 2.

Table 2

Phased Implementation Roadmap¹

Phase	Timeframe	Key Tasks	Expected Outcomes
Short-term	1-2 years	Determine carrying capacities; launch appointment platform; deploy monitoring at key monuments; personnel training	Carrying capacity standards issued; appointment platform operational; monitoring coverage at key sites
Medium-term	3-5 years	Complete digital acquisition of core heritage; build digital exhibition center; scale mahalla tourism; establish unified heritage agency	Digital substitution mechanism established; community participation significantly increased; unified management operational
Long-term	5-10 years	Improve regulatory system; deepen international cooperation; form promotable "Samarkand Model"	Heritage protection and tourism development achieve virtuous cycle; benchmark for Central Asian heritage tourism

Table 2 shows that the roadmap moves from basic tools to institutional consolidation. In the short term (1-2 years), the priority is to determine carrying capacities, launch the appointment platform, deploy monitoring at key monuments, and train personnel. In the medium term (3-5 years), digital acquisition of core heritage, a digital exhibition center, scaled-up mahalla tourism, and a unified heritage agency are expected to establish the digital substitution mechanism and raise community participation. In the long term (5-10 years), an improved regulatory system and deeper international cooperation should allow a transferable "Samarkand Model" to take shape. Each phase builds on the previous one, so that technical measures are backed by the institutions needed to sustain them.

CONCLUSION AND SUGGESTIONS

This paper set out to do two things: to develop a theoretically grounded framework for sustainable tourism flow governance at cultural heritage sites, and to test that framework through a concrete comparison between Dunhuang and Samarkand. The resulting model-resource reduction, digital substitution, social circulation, and governance assurance-should be read not as a universal prescription but as a diagnostic tool. It helps identify which mechanisms are in place, which are missing, and what institutional conditions would be needed to activate them.

The core insight from the Dunhuang case is deceptively simple: heritage sites can transform uncontrollable flow outbreaks into governable flow steady states, but only through deliberate institutional design. The daily cap of 6,000 visitors works not because it is a magic number but because it is backed by a command center, real-time

¹ Source: developed by the author.

data, a digital exhibition center that absorbs demand, a monitoring platform that detects risk, and a specialized legal framework that gives the system teeth. Remove any one of these elements and the cap becomes merely aspirational. This is the lesson that Samarkand-and, I would argue, many other heritage cities along the Silk Road-most needs to absorb: flow governance is not a single policy but a system.

For Samarkand specifically, the adaptation pathway must account for three structural differences from Dunhuang. First, Samarkand's heritage is geographically dispersed across multiple independent monuments and their surrounding neighborhoods, whereas Dunhuang's caves are concentrated in a single managed precinct. This means that carrying capacity assessment and visitor scheduling cannot be centralized in the same way; they require a networked approach that coordinates across sites while respecting each site's conservation constraints. Second, the mahalla system-Samarkand's traditional neighborhood governance structure-represents an institutional resource that Dunhuang does not have in the same form. If properly engaged, mahallas could become the primary vehicle for social circulation, distributing tourism benefits more evenly and building community buy-in for conservation measures. Third, Samarkand's current multi-sectoral fragmentation means that institutional building-not technical implementation-should be the first priority. A unified heritage management agency, even a small one, would do more to improve outcomes in the short term than any number of sensor deployments.

The policy implications follow from this analysis. A unified appointment platform should be built, but it cannot function without first conducting scientifically grounded carrying capacity assessments. Heritage digitization should proceed, but it should prioritize the most fragile and most visited monuments rather than attempting comprehensive coverage from the start. Community benefit-sharing mechanisms should be designed in partnership with mahalla leaders and the Hunarmand Association, not imposed from above. And international cooperation-particularly with the Dunhuang Academy-should focus on capacity building and technical training rather than one-off equipment donations.

This study has limitations that should be acknowledged. The fieldwork, while immersive, was conducted over a single academic year and relied heavily on informal interviews and observation rather than structured survey data. Some figures-particularly those related to visitor flows and economic impact-come from official statistics whose methodologies I was not able to independently verify. As a phased outcome of a larger research project, this paper focuses on the sustainable governance plateau and does not attempt quantitative modeling of flow outbreak mechanisms or efficiency evaluation of flow monetization; these are natural next steps. Future research could also expand the comparison to include Bukhara, Khiva, and Merv, which would allow for a more systematic assessment of how the four mechanisms function across different institutional and cultural contexts. Tracking Samarkand's policy implementation over the coming years-particularly whether a unified management agency is established and whether carrying capacity assessments are actually conducted-would provide a valuable longitudinal test of the framework proposed here.

The broader significance of this study, I believe, lies in its attempt to bridge two conversations that have largely proceeded separately: the literature on tourism flow economy, which is rich in analysis of viral phenomena and monetization but thin on heritage-specific governance; and the literature on circular bioeconomy, which is conceptually powerful but has been applied almost exclusively to agricultural and industrial systems. By bringing these conversations into dialogue, and by grounding the resulting framework in the concrete realities of two Silk Road heritage cities, this paper hopes to contribute to a more systematic approach to managing the flows that will only intensify as heritage tourism continues to grow.

Based on the analysis, the following recommendations are proposed for Samarkand:

1. Conduct scientifically grounded carrying capacity assessments for Registan Square, Gur-e-Amir, Bibi-Khanyim, and Shah-i-Zinda before launching visitor caps.
2. Build a unified electronic appointment platform with time-slot booking, tiered ticket prices, and off-peak prompts, coordinated by the State Committee for Tourism.
3. Prioritize high-precision digitization of the most fragile and most visited monuments, and create a digital exhibition center and a "Cloud Tour Samarkand" service.
4. Deploy preventive micro-environment monitoring in enclosed monuments and link it with meteorological services.
5. Establish a unified Samarkand heritage management agency and prepare special regulations for the protection of the World Heritage site.
6. Design community benefit-sharing mechanisms, including a community tourism development fund, together with mahalla leaders and the Hunarmand Association.
7. Focus international cooperation, particularly with the Dunhuang Academy and within UNESCO programs, on capacity building and technical training.

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