



Digital Technology Utilization by Beginner Hikers: Safety and Technopreneurship Perspectives in Nature Tourism

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ABSTRACT

This study analyzed digital technology utilization by beginner hikers to propose a safety-driven platform architecture integrating outdoor risk management and local technopreneurship. The research was motivated by recurring field vulnerabilities in beginner-friendly mountains, utilizing a multiple-case representation of Mount Gamkonora and Mount Prau. These locations represented contrasting profiles: unmapped, infrastructure-limited terrains versus highly accessible open-trip environments. Despite their differences, both destinations shared critical safety gaps, including navigational deficits and the dangerous bypass of pre-hike physical readiness assessments. A descriptive qualitative approach was employed through semi-structured interviews with eight beginner hikers. The thematic analysis revealed severe navigation difficulties, limited supporting facilities, managerial deficits in commercial trips, and an urgent need for offline-accessible information. Findings demonstrated that these hazards could be mitigated through smart tourism technologies, specifically utilizing offline maps, virtual basecamps, automated physical supply calculators, and verified local service marketplaces. This study concluded that localizing digital solutions effectively addressed immediate physical and psychological hazards while generating sustainable economic value for local communities.

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1. Introduction

Mountain hiking has emerged as a globally popular form of nature tourism, driven by a growing trend among travelers to seek recreation, self-exploration, and direct engagement with the natural environment. Nature-based tourism connects individuals with pristine landscapes, promoting physical well-being, psychological restoration, and sustainable local economic development [1]. In this context, the availability of comprehensive tourist amenities and preparation spaces directly impacts tourist satisfaction and safety compliance in mountain adventure tourism [2].

However, mountaineering and hiking are inherently high-risk outdoor activities characterized by rugged terrains, extreme weather conditions, and environmental unpredictability. Previous research on the psychology of mountaineering emphasizes that risk perception, emotional regulation, and decision-making under uncertainty are critical factors for human safety in high-altitude environments [3]. This risk perception significantly influences a hiker's intention to participate and continue the activity safely [4]. In commercialized mountain destinations, there is frequently a dangerous mismatch between hikers' enthusiasm and their actual navigational competence [5]. For beginner hikers, the lack of destination readiness

transforms a promising nature-based activity into a highly life-threatening endeavor [6], necessitating robust risk communication and stakeholder engagement at the destination [7].

To mitigate these severe risks, recent literature heavily advocates for the integration of Smart Tourism Technologies (STT). Digital technologies and STT offer pragmatic mechanisms to reduce uncertainties, significantly improving tourist experiences, and supporting complex decision-making in the field [8]. This digital transformation has led to the smart development of destinations, where digital tools function as primary navigational aids [9]. Systematic reviews confirm that the implementation of STT profoundly impacts overall tourist satisfaction and safety [10]. Furthermore, mobile applications uniquely change the tourist experience by offering real-time, on-the-go planning and connectivity [11], which are essential metrics when validating the smart tourism experience scale [12].

Translating these digital solutions into sustainable destination management requires a robust business framework. Integrating technology into travel operations relies heavily on digital business model innovations [13], supported by a multidisciplinary approach to digital transformation [14]. By leveraging digital technologies through a technopreneurship approach, local communities can transition into digital entrepreneurs, offering integrated services such as verified guide bookings and virtual basecamps [15]. This cross-sectoral cooperation between technology and local actors is proven to drive sustainable local development [16].

Despite the extensive literature on smart tourism and digital transformation, a significant research gap remains. The majority of STT research predominantly focuses on urban smart cities or destinations with stable infrastructures. Significantly less attention has been directed toward remote nature destinations with fragmented management and unstable network signals. To address this, this study strategically investigates field vulnerabilities by taking a multiple-case representation of two highly popular beginner hiking destinations: Mount Gamkonora and Mount Prau. Mount Gamkonora represents a "difficult and unmapped" terrain where the total absence of clear directional signage and temporary shelters forces hikers to navigate with minimal information. Conversely, Mount Prau represents an "easy and highly accessible" terrain dominated by commercial "open trip" systems. Because the terrain is widely promoted as easy, beginners often bypass physical readiness assessments. Clinical research confirms that the lack of physical preparation severely increases the risk of exhaustion and acute mountain sickness among novices [17].

Therefore, this study aims to analyze digital technology utilization by beginner hikers and propose a safety-driven digital platform architecture that integrates outdoor risk management with local technopreneurship. The novelty of this research lies in applying smart tourism technologies to systematically address the dual challenges of navigational deficits in unmapped terrains (Gamkonora) and managerial/empathy deficits in accessible open trips (Prau), thereby fostering safer hiking experiences while generating sustainable economic value.

2. Research Method

This study employed a descriptive qualitative approach with an exploratory design, focusing on understanding the in-depth experiences, perceptions, and digital needs of beginner hikers during the Mount Gamkonora and Mount Prau hiking activities. A qualitative design was deemed highly suitable because the research problem involved subjective experiences regarding safety concerns, infrastructure limitations, and the perceived usefulness of digital solutions. The primary objective was not statistical generalization, but rather to obtain a profound understanding of the specific field vulnerabilities experienced by novice hikers across different mountain typologies and how those problems could be translated into viable digital service opportunities. Previous studies in outdoor recreation research have consistently demonstrated that qualitative approaches are the most effective method for capturing the nuanced psychological and navigational challenges faced by novice mountaineers [3], [5].

In the context of this study, "beginner hikers" were operationally defined as individuals possessing limited outdoor navigation experience, who have not yet developed strong independent survival or route-reading skills, and who remain highly dependent on external route guidance, facility information, and guide or porter assistance when traversing unfamiliar mountain terrains. Informants were selected using a purposive sampling technique to ensure that participants had direct and relevant experience with the phenomenon being examined. The inclusion criteria required informants to be aged between 18 and 35 years, fit the operational definition of a beginner hiker, have recently participated in a Mount Gamkonora or Mount Prau hiking activity, and be willing to undergo semi-structured interviews.

A total of eight informants were recruited for this study. While this sample size may appear small, it is considered highly adequate for an exploratory qualitative study utilizing reflexive thematic analysis. In qualitative research, the adequacy of a sample is determined by the depth, richness, and conceptual power of the data rather than statistical representation; a smaller, highly relevant sample allows the researcher to achieve deep engagement with the text and generate rich, multifaceted themes [18]. Thus, the focus was

firmly placed on identifying recurring patterns and practical field problems rather than achieving broad demographic generalizability.

Strict ethical considerations were applied throughout the data collection process. Prior to the interviews, all participants were fully informed about the purpose of the study and provided their explicit informed consent. Participation was entirely voluntary, and participants retained the right to withdraw from the study at any time without consequence. To ensure privacy and confidentiality, the identities of the informants were strictly anonymized and assigned alphanumeric codes (I1 to I8) in all transcripts and reports. Furthermore, the researchers guaranteed that all collected data, including audio recordings and transcripts, were securely stored and utilized exclusively for academic and research purposes.

Data acquisition was conducted through semi-structured interviews shortly after the completion of the hiking activities. The semi-structured format allowed the researcher to maintain a clear focus while providing informants with sufficient flexibility to narrate their experiences naturally. To ensure a comprehensive exploration of the research themes regarding field limitations and technological solutions, the interview guide included the following key questions:

- How did you experience and navigate the hiking route on Mount Gamkonora or Mount Prau given the available trail markers and open trip management?
- What specific difficulties did you encounter in planning your logistics and finding resting points or facilities?
- How crucial was the assistance of local guides or porters for your safety, physical readiness, and decision-making during the hike?
- What specific information did you feel was missing before and during your ascent?
- What features in a digital application would you consider most helpful to prepare for and execute a safe hike in an area with limited infrastructure?

The collected data were analyzed using thematic analysis as the primary research procedure. The analytical process followed a systematic and chronological progression consisting of six phases: data familiarization, initial coding, theme generation, reviewing themes, defining themes, and producing the final report. The analysis was guided by established methodological frameworks in qualitative tourism reporting, which previous studies have utilized to ensure that the transition from raw field data to conceptual digital solutions remains rigorous and transparent [19]. Initial codes were developed from recurring statements in the interview transcripts—such as the perceived length of the hiking route, the absence of directional arrows, reliance on minimal post signboards, the lack of a temporary basecamp, distant registration points, the limited operational hours of the refreshment stall at Post 1, the lack of pre-hike physical readiness assessments, and reliance on empathetic porters. These codes were subsequently grouped into subthemes, including weak route orientation, limited facility access, and inefficient pre-hiking flow, which ultimately formed the main themes discussed in the findings.

Table 1 Characteristics of informants

Code	Age	Gender	Hiking Background	Destination Context	Description
I1	21	Male	Limited	Mount Gamkonora	Beginner hiker
I2	22	Female	Limited	Mount Gamkonora	Beginner hiker
I3	25	Male	Prior experience	Mount Gamkonora	Beginner hiker
I4	23	Female	Prior experience	Mount Gamkonora	Beginner hiker
I5	24	Male	Limited	Mount Prau (Open Trip)	Beginner hiker
I6	22	Female	Limited	Mount Prau (Open Trip)	Beginner hiker
I7	26	Male	Prior experience	Mount Prau (Open Trip)	Beginner hiker
I8	25	Female	Prior experience	Mount Prau (Open Trip)	Beginner hiker

As detailed in Table 1, the selected informants were highly relevant to the study's focus, representing a carefully chosen cross-section of beginner hikers. Four informants experienced the unmapped terrains of Mount Gamkonora, whereas the remaining four provided perspectives from the accessible open trips of Mount Prau. This purposeful composition enabled the study to capture both initial encounters with

difficult mountain infrastructure and broader beginner-level perspectives from slightly more exposed individuals on accessible trails. Crucially, aligning with the established operational definition, informants with prior hiking backgrounds were still categorized as beginner hikers. This classification is justified because their overall skill sets remained fundamentally limited; they consistently demonstrated a lack of independent navigational proficiency and maintained a high dependency on external route information, digital guidance, and local guide or porter assistance when traversing unfamiliar mountain terrains.

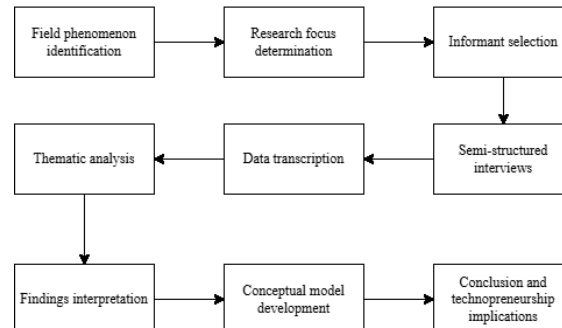


Figure 1 Research methodology flowchart

As illustrated in Figure 1, the research process followed a systematic progression, transitioning from the initial observation of field phenomena to the eventual formulation of actionable business implications. The methodological flowchart encompasses nine sequential stages: (1) field phenomenon identification, (2) research focus determination, (3) informant selection, (4) semi-structured interviews, (5) data transcription, (6) thematic analysis, (7) findings interpretation, (8) conceptual model development, and finally, (9) conclusion and technopreneurship implications. This structured and cohesive flow ensures that the digital platform solutions and technopreneurship opportunities proposed at the end of the study are strictly grounded in the empirical data gathered from the beginner hikers.

3. Result and Discussion

In this section, the results of the research are explained and simultaneously provided with a comprehensive discussion. The thematic analysis of the semi-structured interviews revealed critical areas of concern experienced by beginner hikers on Mount Gamkonora and Mount Prau, which subsequently laid the groundwork for identifying technopreneurship opportunities. The discussion is structured into several sub-chapters to elaborate on the field vulnerabilities across different mountain typologies and translate them into a sustainable digital platform architecture.

3.1. Navigation difficulties in unmapped terrains (Mount Gamkonora)

Navigation difficulty was the most dominant problem identified during the interviews regarding difficult terrains. The informants emphasized that the Mount Gamkonora hiking route felt excessively long and lacked clear directional arrows. The available markers were perceived as insufficient because they were mostly limited to basic signboards located only at designated posts. For beginner hikers, this condition created severe uncertainty because they could not easily judge whether the direction they were following was correct. This navigation issue was strongly validated by the direct statement from Informant 3 (I3):

"Jalurnya cukup jauh dan untuk pendaki pemula bisa terasa membingungkan... Karena tidak ada panah atau petunjuk jalan yang jelas. Penanda yang terlihat hanya plang di tiap pos." (The route is quite long and for beginner hikers, it can feel confusing... Because there are no arrows or clear trail directions. The only visible markers are the signboards at each post).

This problem affected not only physical movement but also psychological safety, as uncertainty on the trail can drastically increase anxiety and reduce confidence. In the context of adventure tourism, elevated risk perception directly impacts cognitive performance and decision-making under stress [3]. Furthermore, excessive psychological burden caused by navigational uncertainty often suppresses the intention to continue the activity safely [4].

3.2. Limited supporting facilities (Mount Gamkonora)

The second theme concerns the severe limitations of supporting facilities at unmapped destinations. The informants highlighted the absence of a temporary basecamp where hikers could adequately rest, prepare, or recover before and after the hiking activity. Informant 4 (I4) explicitly expressed this infrastructural gap:

"Menurut saya belum ada basecamp untuk tempat istirahat sementara... Karena pendaki butuh tempat untuk persiapan sebelum naik atau istirahat setelah turun." (In my opinion, there is no basecamp for temporary rest yet... because hikers need a place to prepare before ascending or to rest after descending).

Furthermore, the availability of logistical supplies along the route was highly uncertain. Informant 2 (I2) stated that the only small refreshment stall was located at Post 1 and did not operate on a reliable schedule:

"Warung hanya ada di Pos 1, dan itu pun belum tentu buka... pendaki tidak bisa bergantung pada warung. Bekal harus disiapkan sendiri dari awal." (The stall is only at Post 1, and even then, it might not be open... Hikers cannot rely on the stall. Supplies must be prepared by themselves from the very beginning).

These conditions forced beginner hikers to make independent, and often inadequate, preparations before entering the trail. The availability of amenities and preparation spaces is fundamentally linked to overall tourist satisfaction and safety compliance in mountain adventure tourism [2].

3.3. Managerial deficits and physical readiness in accessible terrains (Mount Prau)

Conversely, in highly accessible, beginner-friendly terrains represented by Mount Prau, the primary vulnerabilities shifted from physical infrastructure to managerial and human-centric issues. Because the terrain is widely promoted as "easy," beginners often exhibited dangerous overconfidence, frequently bypassing essential physical preparations. Informant 6 (I6) highlighted this systemic flaw within commercial open trips: "Sebelum mendaki, seharusnya ada pengecekan fisik ringan agar peserta tidak kelelahan atau hipotermia di tengah jalan." (Before climbing, there should be a light physical check so participants don't get exhausted or experience hypothermia halfway). Furthermore, the fragmented organization of pre-hiking services worsened this preparation phase. The physical disconnect between registration areas, parking, and briefing points made the preparation process highly inefficient, especially for beginner hikers who required clear, cohesive instructions before entering the route. The critical role of physical activity preparation in preventing severe exhaustion has been proven as a fundamental necessity [17].

3.4. Dependence on local experts and social empathy

Due to the aforementioned uncertainties in both mountain typologies, beginner hikers exhibited a clear and heavy dependence on local guides and porters. In difficult terrains like Gamkonora, this dependence emerged organically because the trail was unclear and the risk of taking the wrong path was exceptionally high. Informant 1 (I1) emphasized their critical role in ensuring navigational safety:

"Iya, karena kalau jalur tidak jelas, guide bisa membantu menunjukkan arah dan mengurangi risiko salah jalan." (Yes, because if the trail is unclear, a guide can help show the direction and reduce the risk of taking the wrong path). Meanwhile, in accessible open-trip setups like Mount Prau, porters function as the primary safety and emotional anchors rather than mere logistical carriers. Informant 7 (I7) stated:

"Porter tidak seharusnya hanya membawa barang, tapi juga memberikan semangat dan memahami kondisi fisik peserta." (Porters shouldn't just carry goods, but also give encouragement and understand the participants' physical conditions).

This reliance aligns with studies on high-risk decision-making, which indicate that novices tend to delegate cognitive risk appraisal entirely to local experts to mitigate their own uncertainties [5].

3.5. Need for offline-accessible and periodically updated digital information

To mitigate the risks associated with navigation, logistics, and physical readiness, there is a critical need for offline-accessible and periodically updated digital information. In remote mountain areas, relying on internet connectivity is highly unrealistic due to the frequent absence of stable network coverage. Informant 3 (I3) expressed the need for:

"Peta offline, informasi pos, dan petunjuk arah jalur." (Offline maps, post information, and trail directions). This was further elaborated by Informant 8 (I8), who stressed the importance of logistical and assessment features:

"Pendaki perlu tahu apakah ada warung atau titik air... Apakah fitur digital seperti checklist logistik akan membantu? Iya, sangat membantu." (Hikers need to know if there are stalls or water points... Would a digital logistics checklist help? Yes, highly helpful).

Digital information in hiking must be highly accurate and locally validated to serve as a reliable safety mechanism [6].

3.6. Digital solutions and technopreneurship opportunities

Translating the identified field problems into a viable digital intervention demands a sustainable technopreneurship business model. The technopreneurship opportunity lies in integrating navigation, route information, logistics planning, physical assessment, and local guide booking into one cohesive digital

ecosystem. To systematically analyze this opportunity, the proposed digital platform is structured around core business model components:

1. **Value Proposition**
The platform offers safer, more organized, and highly reliable hiking preparation tailored for beginner hikers. Its core technological value is the provision of offline-accessible and periodically updated digital information, guaranteeing safety tracking in areas with zero internet connectivity.
2. **Customer Segments**
The primary target users are beginner hikers and open-trip participants. A secondary segment encompasses local guides and porters who need a verified digital space to offer their services.
3. **Key Partners**
Operational sustainability relies heavily on local actors, including guides, porters, destination managers, and regional tourism boards who act as continuous data validators.
4. **Revenue Streams**
The platform employs a "freemium" strategy. Basic offline routes and safety guidelines are free, while revenue is generated through premium map downloads and commission-based local service bookings.
5. **Social Value**
The platform fosters significant social value by improving hiking safety, standardizing emergency response, and empowering the local economy. A sustainable digital platform in tourism must facilitate value co-creation between technology providers, local communities, and tourists themselves, translating technological advancements into direct socio-economic benefits [16]

3.7. Proposed digital platform architecture

The platform must be developed as a safety-driven field-support system rather than a generic promotional website. The architecture emphasizes offline capabilities, validated route data, transparent local service access, and a feedback mechanism for continuous data improvement. Table 2 details the proposed digital platform architecture.

Table 2 Proposed digital platform architecture and features

Module	Main Feature	Required Data Input	System Function
Navigation Module	Offline maps, route tracking, checkpoint markers, and risk point alerts.	Validated GPS route coordinates, local route notes, terrain elevation data.	Guides hikers independently through the trail and reduces route uncertainty.
Preparation & Assessment Module	Equipment checklist, physical readiness form, and logistics supply calculator.	Estimated hiking duration, route difficulty level, user health metrics.	Automates supply estimation and prevents overconfidence on accessible trails.
Virtual Basecamp Module	Digital registration, route briefing videos, and safety SOPs.	User identity data, official route briefing materials, local safety rules.	Organizes pre-hiking preparation more efficiently, substituting the physical basecamp.
Safety Module	Emergency contact directory, offline safety guidelines, and updated weather logs.	Local emergency responder contacts, periodically updated weather forecasts.	Supports safer decision-making in the field during critical situations.
Service Marketplace Module	Verified guide/porter profiles, service packages, and transparent booking.	Provider identity, service competencies, empathy ratings, pricing schemes.	Connects hikers directly with verified, empathetic local services.
Evaluation Module	User feedback, route condition reports, and incident logs.	Post-hiking reviews, submitted route reports, user-generated incident notes.	Functions as a feedback loop to periodically update route data and safety features.

Integrating such modules ensures that intelligent risk prediction and management can be localized effectively [20]. Furthermore, this architecture exemplifies a novel digital business model configuration tailored specifically for the travel industry [13].

3.8. Conceptual model and feedback mechanism

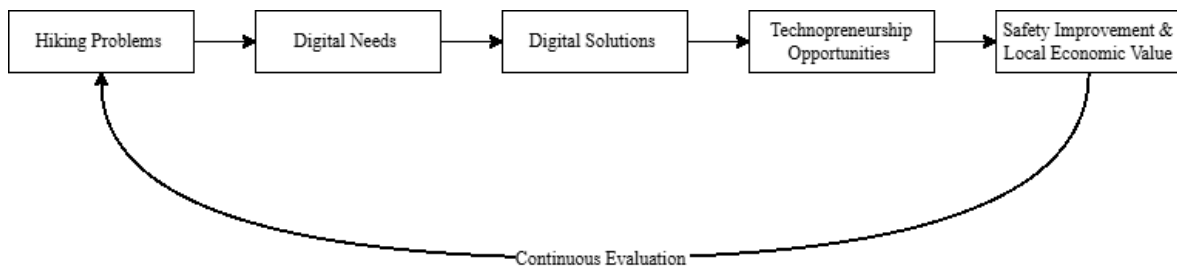


Figure 2 Conceptual model of nature tourism technopreneurship development.

Figure 2 illustrates the integrated conceptual model of nature tourism technopreneurship development. The model begins by addressing Hiking Problems across different mountain typologies, which include unclear trails, limited route information, absence of physical shelters, and managerial gaps in open trips. These gaps are systematically translated into specific Digital Needs, emphasizing features that must remain functional without an internet connection. These localized requirements directly dictate the framework for Digital Solutions, which open up scalable Technopreneurship Opportunities. Crucially, the final output is defined as Safety Improvement and Local Economic Value. Continuous Evaluation acts as a vital feedback loop, continuously gathering post-hiking user reviews and local guide validations to update the ecosystem.

3.9. Practical implications for destination management

The implementation of the proposed model carries direct practical implications. First, the transition from fragmented pre-hiking services to an integrated virtual basecamp can resolve operational inefficiency. By digitizing the registration and physical assessment processes, destination managers can ensure that every beginner hiker receives verified safety protocols before entering the trail. Second, the platform fosters a collaborative network environment where local guides and porters are integrated into a secure marketplace. By providing transparent access to verified local services, the platform eliminates illicit brokering, standardizes service fees, and improves community economic resilience, serving as an inclusive tool for local development [15].

3.10. Open-source considerations and data governance

The sustainability of a safety-driven hiking platform depends heavily on its data governance framework. Utilizing open-source mapping resources represents a collaborative approach to build the initial route database. Open-source mapping can accommodate community-based inputs. However, in high-risk nature tourism, open-source data cannot be utilized without strict institutional validation. Therefore, the platform architecture incorporates a hybrid data governance model where community-generated open-source maps must undergo official cross-checking and validation by local guides and park managers before being pushed as premium offline updates. This rigorous data control mechanism maintains credibility as a life-saving tool.

Table 3 Open-source implementation and data governance considerations

Component	Open-source opportunity	Validation mechanism	Governance concern
Route map data	Community-based route documentation	Local guide and porter verification	Avoiding inaccurate or unsafe route information
Facility updates	Shared reports on basecamp, stall, and resting-point conditions	Periodic local validation	Preventing outdated logistics information
Guide/porter profiles	Transparent service information and availability	Identity and service standard verification	Fair pricing, fair reviews, and local actor protection
User feedback	Continuous route and service improvement	Moderation and cross-checking	Preventing misleading reports and biased ratings

4. Conclusion

This study concludes that beginner hikers across diverse mountain typologies—represented by the unmapped, infrastructure-limited terrain of Mount Gamkonora and the highly accessible open-trip environment of Mount Prau—face critical structural, informational, and managerial challenges. As expected in the Introduction, these field vulnerabilities—ranging from severe navigational difficulties and the absence

of physical shelters to the lack of pre-hike physical readiness assessments—can ultimately be mitigated through a technopreneurship approach, demonstrating a strong compatibility with the digital platform architecture proposed in the Results and Discussion chapter. The empirical findings validate that these physical and psychological hazards are deeply exacerbated by acute information gaps, which can be systematically resolved through localized Smart Tourism Technologies (STT).

Regarding the prospect of research development, translating these immediate field hazards into integrated digital solutions provides a robust foundation for digital business model innovations. The proposed conceptual modules—including offline-accessible navigation, virtual basecamps, automated physical supply calculators, and a verified local service marketplace—demonstrate that digitalization in high-risk nature tourism can simultaneously improve hiker safety and stimulate sustainable local economic participation.

Furthermore, the application prospects for further studies should focus on the technical development, deployment, and beta-testing of a working software prototype based on this proposed architecture. Future research is highly recommended to conduct longitudinal field testing and advanced usability evaluations to empirically validate the system's reliability, offline map accuracy, hybrid data governance protocols, and the long-term socio-economic value generated by this technopreneurship model across a broader spectrum of outdoor destinations.

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