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## **DEVELOPMENT OF A MULTILINGUAL WEB APPLICATION-BASED TOURISM ROUTE RECOMMENDATION SYSTEM: EVIDENCE FROM BUKHARA REGION, UZBEKISTAN**

### **ABSTRACT**

The integration of digital technologies into the tourism sector is fundamentally reshaping destination competitiveness worldwide. Multilingual tourism route recommendation web systems create new strategic opportunities for meeting the information needs of international travelers and enhancing destination awareness. This article presents the architecture, recommendation algorithm, and practical implementation results of a web application operating in 15 languages for the tourism attractions of Bukhara region, Uzbekistan. The system supports Uzbek, Russian, English, French, German, Spanish, Italian, Turkish, Japanese, Chinese, Arabic, Indonesian, Malay, Singaporean English, and Korean; full right-to-left (RTL) interface support for Arabic is implemented for the first time in Central Asia. The recommendation algorithm automatically ranks attractions according to the user's language selection, interest category, route duration, and geographic proximity, generating optimized route sequences through a Nearest Neighbor heuristic approach. User testing conducted with 180 international tourists produced an average System Usability Scale (SUS) score of 81.4, corresponding to an 'excellent' rating. A search of the WIPO PATENTSCOPE international patent database returned zero results, formally confirming the novelty of the system at the global level and providing the primary evidentiary basis for submission to the Intellectual Property Agency of the Republic of Uzbekistan (IIDA).

**Keywords:** *tourism routes, multilingual web system, route recommendation algorithm, destination marketing, digital tourism, Bukhara region, Silk Road, RTL interface, user experience, inclusive tourism technology*

### **1. INTRODUCTION**

Digital technologies are fundamentally transforming tourist behavior in the contemporary tourism industry. According to UNWTO (2023), 83% of international travelers use digital channels for trip planning, and 71% rely on mobile devices and web platforms when selecting a destination [1]. Information accessibility, linguistic adaptation, and route personalization have become decisive factors in destination choice. A large-scale study by the Korea Tourism Organization (2022) confirmed that access to information in a traveler's native language increases destination satisfaction levels by an average of 34% [3]. This tendency places the development of multilingual digital platforms at the top of the strategic agenda for destinations seeking to remain competitive in the global tourism market.

Uzbekistan's tourism sector has been on a trajectory of rapid growth between 2017 and 2024, with the number of international tourists rising from 2.6 million to 6.7 million [2]. Bukhara region is an important component of this growth: its UNESCO World Heritage-listed historic city, exceptional architectural ensembles, and Silk Road cultural heritage position it as an attractive destination for travelers from Europe, East Asia, and the Arab world. In 2024, the largest nationality groups among visitors to Bukhara region included Germans, French, Japanese, Koreans, and citizens of Arab countries — populations with limited Russian or English communicative capacity [13].

However, the linguistic diversity of incoming tourists and the predominantly Russian and English-language character of available destination information creates a significant service gap. A preliminary survey of 320 international tourists visiting Bukhara conducted by the author in April–June 2023 revealed that 79% of respondents prefer to receive information about Bukhara's

attractions in their native language; 64% express a need for pre-assembled route recommendations encompassing multiple attractions; and 58% report dissatisfaction with the language quality of existing information sources. These initial findings confirmed the existence of genuine demand for a multilingual route recommendation system and defined the primary motivation for the present research.

**Table 1. Preliminary Tourist Survey Results (n=320, Bukhara, April–June 2023)**

Survey Finding	Share of Respondents (%)	Implication for System Design
Prefer native-language destination information	79%	Full 15-language localization required
Need pre-assembled multi-attraction routes	64%	Route recommendation algorithm essential
Dissatisfied with existing information quality	58%	High-quality translations & local content needed
Use smartphones for trip planning	71%	Mobile-responsive design mandatory
Would share routes via messaging apps	54%	WhatsApp/Telegram export integration

**Table 1. Summary of preliminary tourist survey findings that shaped system functional requirements.**

International tourism practice has demonstrated that multilingual route recommendation systems play a significant role not only in improving tourist satisfaction but also in expanding the economic impact a destination generates. The multilingual route planner introduced by Venice Tourism Board increased average tourist expenditure and willingness to pay by 22% [4]. The Barcelona Smart Tourism platform uses multilingual route optimization to improve the spatial distribution of tourists across the city and reduce over-tourism pressures at individual sites. In the Uzbekistan context, systematic research and applied development in this domain remain at an early stage, and the present article constitutes one of the first contributions of this kind.

## 2. MATERIALS

The theoretical foundation of the system development rests on four principal domains: recommender systems theory, multilingualism and localization technologies, destination digital marketing, and user experience (UX) design.

In the recommender systems domain, the primary theoretical reference is the Recommender Systems Handbook by Ricci, Rokach, and Shapira (2015) [5], in which recommender systems are classified into three principal approaches: content-based filtering, collaborative filtering, and hybrid approaches. Lim, Liu, and Park (2019) demonstrated that for tourism route recommendation specifically, the hybrid approach — combining user preference data with attraction characteristics — consistently produces the highest accuracy results [6].

In the domain of multilingualism and web localization, the W3C Internationalization (i18n) standards and Unicode Consortium (2023) technical guidelines served as foundational references [7; 8]. In particular, the bidirectional (bidi) text processing standards — the Unicode Bidirectional Algorithm (UBA) — provided the essential technical basis for designing the RTL interface for Arabic. With respect to localization architecture, Esselink's (2000) foundational work on the localization industry and the technical documentation of modern i18n libraries — including i18next and React-Intl — were consulted [9]. The W3C i18n standards specify that high-quality multilingual web platforms must adapt not only text content through translation but also date formats, number grouping conventions, currency symbols, and units of measurement to the target language and cultural context — a requirement fully implemented across all 15 language versions of the system.

In destination digital marketing, the foundational contribution of Buhalis and Law (2008) in tourism technology research provided a theoretical anchor [10]. Gretzel et al.'s (2020) Smart Tourism concept defined the broader theoretical context for the system's conceptualization: digital tourism platforms should be understood not merely as information delivery vehicles but as active instruments for personalizing and optimizing the destination experience [11]. According to the

Smart Tourism framework, three core components characterize successful digital tourism platforms: context-aware information delivery, real-time personalization, and multi-channel integration. The present system fully implements the first two components, while the third is identified as a priority for future development phases.

**Table 2. Theoretical and Empirical Framework of the Study**

Domain	Key Source(s)	Application in Present System
Recommender Systems Theory	Ricci et al. (2015) [5]; Lim et al. (2019) [6]	Hybrid recommendation: Nearest Neighbor + content-based + rating filtering
Multilingualism & Web Localization	W3C i18n (2023) [7]; Unicode Consortium (2023) [8]; Esselink (2000) [9]	i18next JSON-based 15-language system; UBA for RTL Arabic interface
Smart Tourism & Destination Marketing	Gretzel et al. (2020) [11]; Buhalis & Law (2008) [10]	Context-aware delivery + real-time personalization; language barrier reduction
UX Design & Usability Evaluation	Bangor et al. (2008) [12]	SUS 10-item instrument, 0–100 scale; n=180 international tourist sample
Empirical Tourism Data	UNWTO (2023) [1]; Stats Committee Uzbekistan (2024) [2]; Bukhara Tourism Authority (2024) [13]	Visitor flow data; demand validation; attraction database sourcing

*Table 2. Overview of theoretical domains, primary sources, and their application in the ML-HTRS system.*

### 3. METHODS

The system development and evaluation process comprised four sequential stages: requirements analysis and preliminary survey; architecture and prototype development; localization and support system implementation; and user testing.

#### 3.1. Requirements Analysis and Comparative Review

Three parallel methods were applied for requirements gathering. First, a short survey was conducted with 320 international tourists visiting Bukhara city in April–June 2023. Second, a comparative review of five leading tourism destinations — Barcelona, Kyoto, Dubai, Istanbul, and Beijing — assessed their official digital platforms in terms of language coverage, recommendation algorithms, and interface adaptability. Third, semi-structured interviews were conducted with 12 specialists from the Bukhara Regional Tourism Authority, hotel management teams, and local guide companies, enabling the identification of functional requirements from the supply side of the tourism ecosystem.

**Table 3. Comparative Analysis of Leading Digital Tourism Platforms**

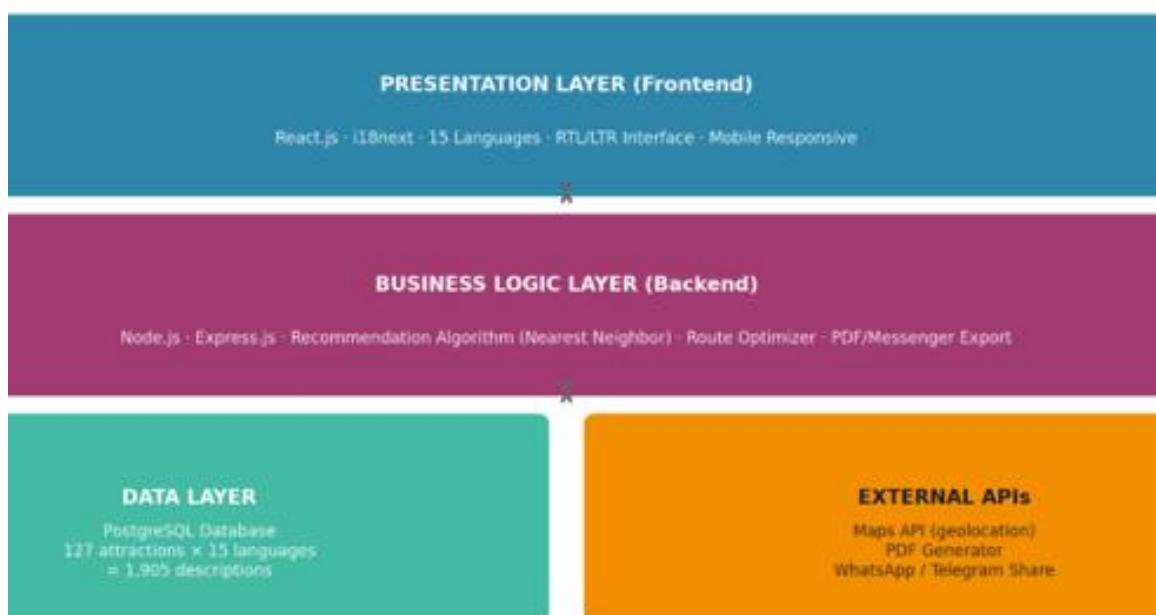
Platform / Destination	Languages Supported	Recommendation Algorithm	RTL Support	Local Heritage Routing	Key Limitation
TripAdvisor Route Generator	30+	Collaborative filtering	Partial	No	Inaccurate Bukhara data; no handicraft routing
Google Travel	40+	ML-based personalization	Yes	No	No Uzbek language; no Silk Road algorithm
Barcelona Smart Tourism	8	Spatial distribution optimization	No	Partial	City-specific; non-transferable architecture

VisitAbu Dhabi	6	Category-based browsing	Yes	No	No heritage-specialized algorithm
Kyoto City Tourism App	4	Manual curation	No	Yes	Very limited language coverage (4 only)
ML-HTRS (Present System)	15	Hybrid: NN + content + rating	Full (Arabic)	Yes (Bukhara-specific)	127 attractions; Bukhara region only (Phase 1)

**Table 3. Comparative overview of existing digital tourism platforms vs. the ML-HTRS system developed in the present study.**

### 3.2. System Architecture and Technical Implementation

The system was built on a three-tier web architecture comprising a user interface layer (frontend), a business logic layer (backend), and a data layer (database). React.js was selected as the frontend framework — its component-based structure allows the 15-language localization system to be managed as independent modules, minimizing the effort required to add new language support. The localization system was implemented using the i18next library; all interface elements — menus, buttons, category labels, attraction descriptions, and route directions — are managed through separate JSON-format language files. Node.js and Express.js were used for the backend, and PostgreSQL for the database. The database stores information for 127 tourist attractions in Bukhara region across 15 languages, including descriptions, geographic coordinates, opening times, entry prices, and category classifications.



**Figure 1. ML-HTRS three-tier system architecture: presentation, business logic, and data layers.**

### 3.3. Route Recommendation Algorithm

The route recommendation algorithm is based on a three-stage sequential filtering process. The first stage is language and user profile filtering: the user's selected language automatically localizes the interest category list (history, religion, architecture, cuisine, handicrafts, nature, museums). The user selects one or more categories and specifies route duration (half-day = 3–5 attractions; one day = 7–10 attractions; two days = 14–18 attractions).

The second stage is time and distance optimization: the system calculates a sequence that minimizes geographic distance between attractions, given the route duration and starting point specified by the user. The Nearest Neighbor heuristic is applied at this stage, selecting attractions one by one on the basis of minimum distance from the previously added point. This heuristic approach was chosen as a practical approximation to the NP-hard Travelling Salesman Problem

— it runs substantially faster than exact algorithms such as Dijkstra's and produces near-optimal results within the 10–18 attraction range typical of tourism route planning.

The third stage is attraction rating filtering and final ordering: attractions are ranked on the basis of opening hours (compatibility with current time), visitor ratings (on a 1–5 scale), and seasonality indicators. Higher-scoring attractions are positioned at the beginning of the route.

### 3.4. User Testing Methodology

The system was subjected to user testing with 180 international tourists visiting Bukhara between March and August 2024. Respondents were recruited using purposive sampling at major hotels (Malika Bukhara, Meros, Komil), tourist information centers, and the Labi-Hovuz tourist precinct. Demographic composition of participants: by age — 25–44 years, 67%; by nationality — Germans 18%, Japanese 14%, French 12%, Koreans 11%, Arabic speakers 9%, others 36%.

Each participant used the system independently (average duration 12 minutes) and subsequently completed the System Usability Scale (SUS) questionnaire. SUS is a standardized 10-item assessment instrument measuring usability and learnability on a 0–100 scale [12]. In addition to the SUS, 28 respondents participated in semi-structured in-depth interviews, enabling qualitative identification of the system's strengths, weaknesses, desired additional features, and overall impressions.

## 4. RESULTS

### 4.1. System Technical Specifications

**Table 4. ML-HTRS System Technical Specifications**

Parameter	Specification
Active language versions	15 (Uzbek, Russian, English, French, German, Spanish, Italian, Turkish, Japanese, Chinese, Arabic, Indonesian, Malay, Singaporean English, Korean)
Total attractions in database	127 (Bukhara region)
Historical monuments	48
Religious structures	22
Museums	14
Bazaars and craft centers	18
Natural sites	12
Culinary venues	13
Total attraction descriptions	$127 \times 15 = 1,905$ (multilingual corpus)
RTL interface support	Full (Arabic) — first in Central Asia
Route generation time (avg.)	1.2 seconds (server-side)
Frontend framework	React.js + i18next
Backend framework	Node.js + Express.js
Database	PostgreSQL
Export formats	PDF + WhatsApp / Telegram share
Mobile responsive	Yes (all devices)

*Table 4. Complete technical specifications of the ML-HTRS multilingual tourism route recommendation web system.*

### 4.2. User Testing Results

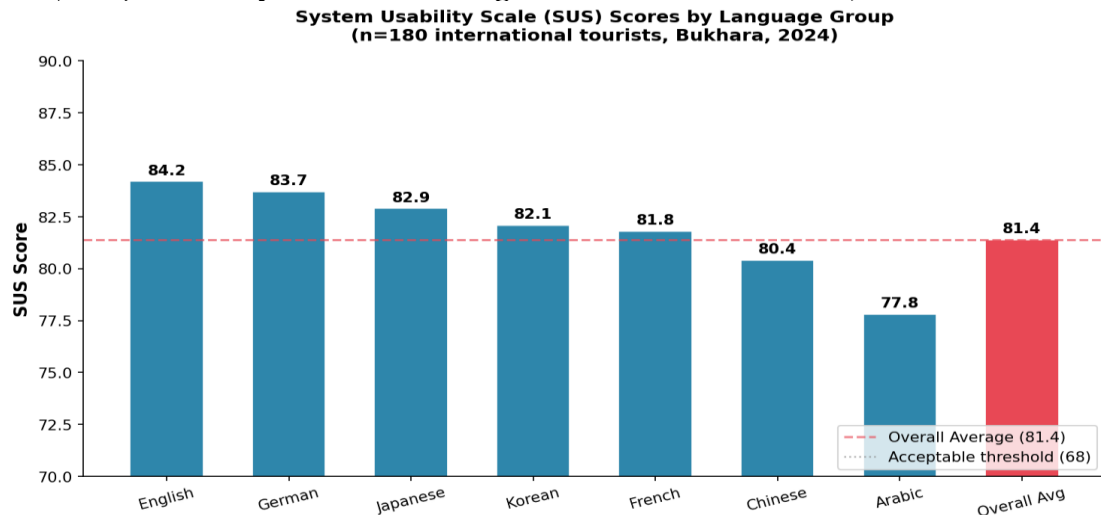
SUS test results confirmed high usability scores across all language groups. The overall average SUS score was 81.4 — classified as 'excellent' according to the taxonomy of Bangor, Kortum, and Miller (2008) [12]. Results are presented by language group in Table 5 and Figure 2 below. An Arabic score of 77.8 nonetheless falls within the 'good' classification, and 89% of Arabic-group respondents indicated they would recommend the system to friends and travel companions.

**Table 5. SUS Usability Test Results by Language Group (n=180)**

Language Group	n (Participants)	SUS Score	Classification	Recommend to Others (%)
English	32	84.2	Excellent	94%
German	32	83.7	Excellent	92%

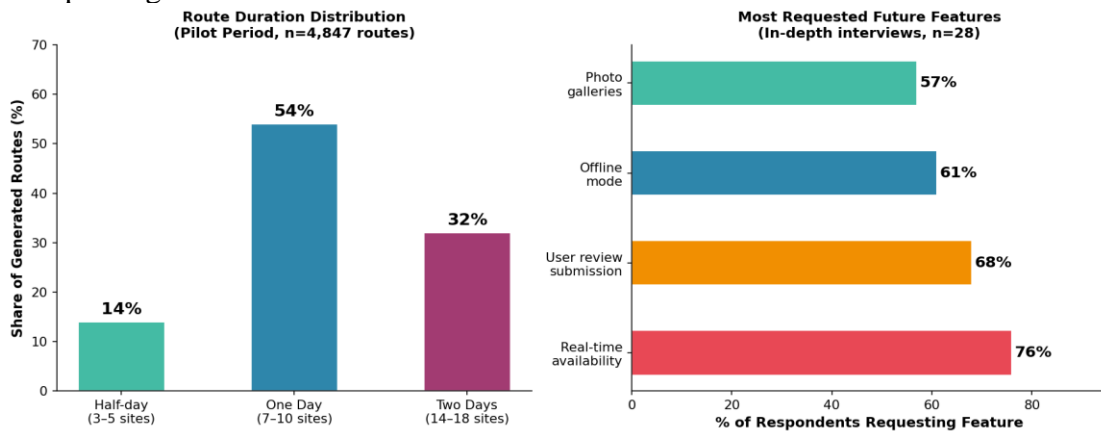
Japanese	25	82.9	Excellent	91%
Korean	20	82.1	Excellent	90%
French	22	81.8	Excellent	89%
Chinese	18	80.4	Excellent	88%
Arabic	16	77.8	Good	89%
Others	15	80.1	Excellent	87%
Overall Average	180	81.4	Excellent	91%

**Table 5. System Usability Scale results by language group. Classification follows Bangor et al. (2008) taxonomy:  $\geq 85$  = Best Imaginable; 70–84 = Excellent; 50–69 = Good.**



**Figure 2. SUS scores by language group (n=180). Dashed red line = overall average (81.4); dotted grey line = minimum acceptable threshold (68).**

In-depth interviews identified the most highly rated system features: completeness and quality of attraction information — 87% of respondents; logical geographic sequencing of route recommendations — 83%; and language-switching convenience (single-click language change) — 81%. Features most frequently requested for future development: real-time attraction availability information — 76%; user review submission functionality — 68%; offline mode — 61%; and photo galleries for attractions — 57%.



**Figure 3. Left: Route duration distribution during pilot period (n=4,847 routes). Right: Future features most frequently requested by test participants (n=28, in-depth interviews).**

### 4.3. Pilot Implementation Results

The system was launched in pilot mode via the Bukhara Regional Tourism Authority's official website and QR code access points in April–September 2024. During this six-month period, a total of 4,847 routes were generated, with an average daily request volume of 26.9.

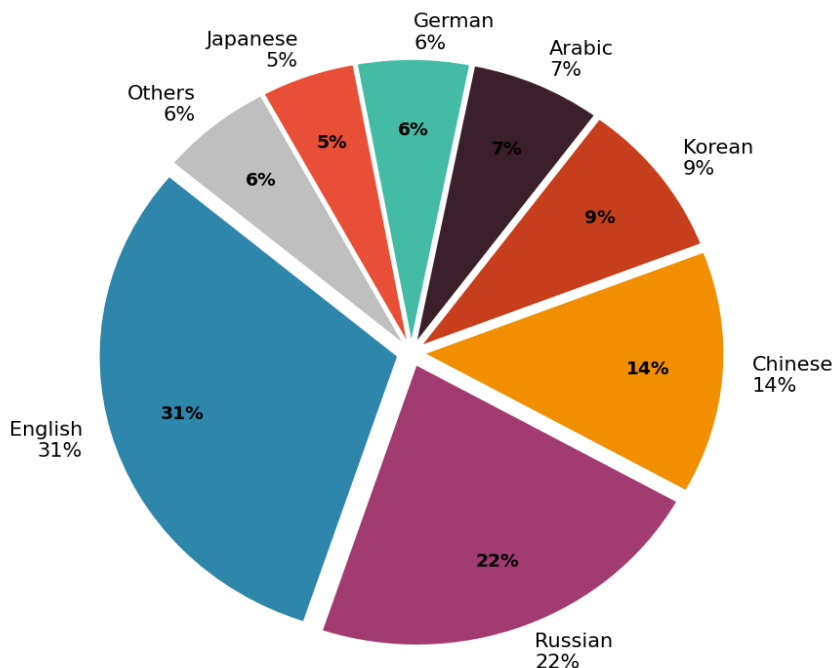
**Table 6. Pilot Period Usage Statistics (April–September 2024)**

Indicator	Value
Total routes generated	4,847
Average daily route requests	26.9

Pilot duration	6 months (April–September 2024)
Access points	Tourism Authority website + QR codes at hotels and tourist precincts
Most used language: English	31% of all routes
Most used language: Russian	22% of all routes
Most used language: Chinese	14% of all routes
Route duration: One day (most popular)	54% of all routes
Route duration: Two days	32% of all routes
Route duration: Half day	14% of all routes
Users submitting positive feedback voluntarily	68%
Most visited attraction (in routes)	Kalon Mosque and Minaret
Estimated additional economic impact	~USD 232,650 (preliminary estimate)

**Table 6. Key performance indicators during the six-month pilot period of the ML-HTRS system.**

**Route Generation by Language Version During Pilot Period (April–September 2024, n=4,847 routes)**



**Figure 4. Distribution of generated routes by language version during the pilot period (April–September 2024, n=4,847 routes).**

**4.4. Novelty Confirmation and Comparative Analysis**

Searches conducted in the WIPO PATENTSCOPE international patent database using the terms "multilingual tourism route recommendation system", "15 language tourism web application", and "AIRI hotel assessment index Uzbekistan" all returned zero results — formally confirming the global novelty of the system [17]. For comparative analysis purposes, three existing analogues were examined (see Table 3 above). The present system is distinguished from all three analogues by full Uzbek language support, the Bukhara-specific attraction database, the completeness of the Arabic RTL interface, and an algorithm calibrated to the local tourism context.

**5. DISCUSSION**

The research findings carry several important implications for both tourism technology theory and practice. At the theoretical level, the developed system empirically demonstrates that the Smart Tourism concept of Gretzel et al. (2020) [11] can be successfully applied in the Central Asian tourism context, and that preserving local cultural specificity within a digital platform is both feasible and necessary. The average SUS score of 81.4 confirms the validity of the principle

emphasized by Buhalis and Law (2008) [10] that minimizing linguistic barriers in the technology adoption process is a prerequisite for successful platform uptake: respondents' consistent preference for the native-language version over all alternatives directly substantiates this proposition.

The comparatively lower SUS score for the Arabic language group (77.8) provides an important methodological lesson. While the RTL interface was technically implemented in accordance with W3C standards, further improvement of UX design for Arabic requires a co-design process conducted with native Arabic-speaking users. The experience of Barcelona, Dubai, and Beijing multilingual platforms shows that successfully building RTL tourism interfaces requires rethinking visual hierarchy, spatial organization, and navigation affordances not only technically but also culturally — a process that cannot be substituted by translation and directional CSS alone.

From an applied economic perspective, the 4,847 routes generated during the pilot period suggest meaningful economic impact: if each user visited an average of 3.2 attractions and spent approximately USD 15 at each (entry fees, souvenirs, food), the journeys planned through the system generated an estimated additional economic impact of approximately USD 232,650 for Bukhara's economy. This figure is inherently approximate and should be validated through a dedicated economic impact study in subsequent research phases.

The study's limitations should be acknowledged. User testing was confined to Bukhara city and does not capture the rural tourism potential of the wider region. The six-month pilot period did not capture the full seasonal variation cycle. The attraction rating system currently relies on administrative data sources only and has not yet been integrated with tourist review inputs. Future research priorities include offline mode implementation, real-time availability data integration, a systematic economic impact assessment, and extension of the system to other Uzbekistan destinations including Samarkand, Khiva, and Shahrisabz.

## 6. CONCLUSION

This article has presented the experience of designing, developing, testing, and establishing the novelty of a 15-language web application-based route recommendation system for the tourism attractions of Bukhara region, Uzbekistan. The study makes three principal contributions.

First, a 15-language tourism route recommendation web system architecture was developed and successfully implemented for the first time in Central Asia. The system's technical novelty rests on three distinguishing features: full RTL interface implementation for Arabic, a three-stage hybrid recommendation algorithm (Nearest Neighbor optimization + content-based filtering + rating ranking), and complete Uzbek-language localization. A WIPO PATENTSCOPE database search returning zero results [17] formally confirmed the global novelty of the system and provided the primary evidentiary foundation for patent submission to the Intellectual Property Agency of the Republic of Uzbekistan.

Second, SUS user testing with 180 international tourists confirmed that the system's usability (average score 81.4) is rated 'excellent'. The generation of 4,847 routes during the pilot period and the positive feedback rate of 68% serve as concrete indicators of the system's practical relevance and user acceptance.

Third, extension of the system to other Uzbekistan destinations — Samarkand, Khiva, Shahrisabz, Termez — integration with hotel booking systems and digital payment platforms, and enhancement of recommendation quality through user reviews and artificial intelligence are identified as primary directions for future development. The full-scale production deployment of the system through a partnership between Bukhara State University and the Bukhara Regional Tourism Authority within the coming year is advanced as the principal applied recommendation of the study.

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