Coastal Tourism: Enhancing Beach Suitability and Safety by Using Machine Learning

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Abstract:

To create a safety enhancement in tourism we are building an application on recreational suitability assessment system for Indian beaches. "Tour The Beach" application is designed as a user-friendly digital tool for tourists seeking to enjoy Indian beaches safely and with greater insight. Tailored for travelers and adventure-seekers, this app consolidates essential beachrelated data such as tidal information, rainfall, weather conditions, wind speed, and water quality, providing a comprehensive safety overview. Each of these parameters is displayed on a per-beach basis, ensuring that users have location-specific insights that can aid them in making informed decisions. The app's primary goal is to enhance safety by supplying real-time, location-relevant data that users can easily interpret and apply to their travel plans. Beyond safety features, the " Tour The Beach " app offers an integrated social sharing function, allowing users to seamlessly share their experiences or updates with friends and family across social media platforms. Additionally, the app's distance-checking feature helps travelers calculate distances between their current location and selected beaches, making planning even more convenient. By providing a list of available beaches in India, the application encourages exploration while promoting responsible travel and awareness of environmental factors that may affect a visit. With this blend of practical information and user-friendly tools, " Tour The Beach " aims to support beach tourism in India by ensuring that users are equipped with the essential knowledge to enjoy their beach visits responsibly and safely. The app thus stands as a crucial companion for any beachgoer, promoting both tourism and safety in coastal regions across the country.

1. INTRODUCTION

1.1 Purpose

This paper aims to develop a comprehensive mobile application designed to assess the suitability of beaches across India for various recreational activities. The application will utilize real-time oceanic and meteorological data from the Indian National Centre for Ocean Information Services (INCOIS). The data collected will include crucial environmental factors such as wave height, wind speed, rainfall, tides, water temperature, and water quality. This range of data will allow the app to analyze and determine beach conditions, ensuring that the information provided is accurate and current. The app will deliver real-time safety alerts and recommendations to beachgoers by processing and analyzing these environmental variables. For instance, during unfavorable conditions like high waves or strong winds, users will be alerted and advised to avoid visiting specific beaches. On the other hand, when conditions are ideal for recreational activities, such as swimming, surfing, or sunbathing, the app will notify users, encouraging them to enjoy the beach safely.

1.2 Motivation

This mobile application aims to make beach tourism in India safer, more enjoyable, and more sustainable. India has a vast coastline of over 7,500 kilometers, offering incredible opportunities for beach activities. However, tourists often worry about safety because of unexpected weather changes, strong ocean waves, and concerns about water quality. These issues can discourage people from enjoying the beach. To solve this, the app will use real-time data from the Indian National Centre for Ocean Information Services (INCOIS) to provide safety alerts and recommendations, helping users make better decisions. Tourists will be informed about changing weather, wave conditions, and water quality, so they can decide the best times and places to visit. This feature aims to prevent accidents and improve beach experiences. The app also encourages sustainable tourism by promoting safe beach practices and raising awareness about protecting the coastal environment. By helping tourists avoid dangerous conditions and supporting local economies, the project combines tourism growth with environmental responsibility.

Currently, many beachgoers lack access to up-to-date information about ocean and weather conditions, which can lead to risky choices. This app fills that gap by providing tourists with essential data, so they can plan safer and more enjoyable beach trips. As more people visit India's beaches, having such reliable safety tools is increasingly important to ensure that everyone can enjoy a secure and memorable experience by the sea.

2. LITERATURE SURVEY

This paper focuses on the development of a mobile application specifically designed to provide accessible beach information for tourists with disabilities. The authors emphasize the need to address physical accessibility, such as wheelchair access points, accessible restrooms, and transportation options, along with real-time data on crowd levels and safety alerts. The study introduces innovative features like customizable text sizes, audio navigation, and real-time alerts on beach conditions to ensure inclusivity. The research provides a valuable perspective for Samudra in building an inclusive beach information system that caters to the diverse needs of all beachgoers, particularly emphasizing the importance of accessibility and personalization in recreational suitability assessments.[7] This study presents a framework for a beachcombing service system that integrates the principles of marine ecotourism to create sustainable and environmentally friendly beach tourism. The authors emphasize the importance of preserving marine biodiversity while catering to tourists' needs, proposing a system that provides real-time information on environmental conditions, biodiversity hotspots, and eco-friendly activities at beaches. By offering visitors an ecoconscious tourism experience, the system aims to raise awareness of marine conservation and promote responsible tourism. The paper's insights contribute to developing a beach information system that balances recreational suitability with environmental sustainability, aligning well with the goals of an Indian beach assessment app focused on safe and informed beach visits.[2] This study proposes a Social IoT-based system that monitors beach occupancy and provides real-time overcrowding alerts to encourage sustainable beach tourism. By tracking crowd levels and sharing this information with tourists, the system helps distribute visitor traffic, preventing environmental degradation and enhancing tourist safety. The authors incorporate IoT sensors to collect occupancy data and offer insights on less crowded beach areas or alternative times for visiting. The findings illustrate the potential of IoT integration in beach tourism applications, offering a sustainable approach to managing beach resources and reducing environmental impact. This paper's approach to monitoring crowd levels and promoting sustainable beach use aligns well with Samudra's objectives of supporting safe and enjoyable beach experiences through real time information and sustainable tourism practices.[6] This research explores a mobile application designed to centralize and distribute tourist information on beaches in the La Libertad region, aiming to improve visitors' access to essential amenities and recreational options. The application provides real time updates on beach conditions, safety warnings, weather information, and the availability of amenities, enhancing the tourist experience through data-driven insights. The authors emphasize usability and intuitive design, which encourage user engagement. This study highlights the effectiveness of digital platforms in organizing and disseminating tourist information, underscoring the need for user friendly interfaces and real-time updates in beach suitability applications. The findings are relevant for the Samudra app, as they provide a foundation for creating an efficient and accessible information system tailored to tourists' needs.[1]

3. METHODOLOGY

3.1 Existing System

The SAMUDRA app is a comprehensive tool designed to provide real-time information and enhance the safety and planning of beachgoers, tourists, and coastal communities. With a focus on Indian beaches, the app offers valuable data on weather conditions, tidal patterns, wind speed, water quality, and more, helping users make informed decisions about their beach visits. for tourists and beachgoers, SAMUDRA provides key information such as distance from their location to nearby beaches, making travel planning more convenient. Coastal communities can also benefit from the app by staying informed about changing beach conditions, helping them prepare for tides, weather changes, or other environmental factors. While it currently focuses on beaches in India, the app is designed to offer accurate and up-to-date data, with a visually engaging frontend to ensure ease of use. However, it currently lacks future predictions for conditions like tides or weather forecasts. Overall, SAMUDRA serves as an essential tool for beach enthusiasts, enhancing both safety and convenience in planning beach visits.

Advantages

- Intuitive and visually appealing design with vibrant, beach-inspired colors.
- Provides real-time weather, tidal data, wind speed, and water quality information.
- Social sharing options to easily share beach details with friends and family.
- Distance-checking feature to assess travel feasibility to nearby beaches.
- Ensures safer beach visits with accurate and relevant data.

Disadvantages

- Does not offer future forecasts for weather, tides, or other beach conditions.
- Requires an internet connection, making it less useful in remote or offline areas.
- This does not include all the beaches in India.
- Dependent on real-time data accuracy, which may affect user experience if data is delayed or incorrect.

Limitations

- Limited to frontend development; does not include backend functionality.
- May require frequent updates to maintain accuracy of beach data (e.g., weather, tides).
- Relies on internet connectivity for real-time information, limiting use in remote areas.
- Currently focuses only on beaches in India, limiting global usability.
- Does not provide future predictions for weather, tides, or other beach conditions.

3.2 Proposed System

The proposed system is dedicated to develop a comprehensive mobile application that provides real-time safety assessments for beaches.This application will gather and analyze realtime oceanic and meteorological data from authoritative sources and other relevant agencies, to ensure that users have access to accurate, timely information. By integrating essential environmental data points such as wave height, wind speed, rainfall, and water quality, the system will deliver a robust assessment of beach conditions. The application's primary focus is to offer personalized safety alerts and recommendations tailored to each user. This means that beachgoers will be able to receive immediate updates regarding the current safety levels at their chosen beach location. For example, if there are high waves, strong winds, or compromised water quality, the system will issue an alert to inform users of potential risks and advise them to take appropriate precautions or avoid certain beach areas. By providing these real-time insights, the application not only prioritizes the safety of individual users but also enhances their overall beach experience. Users can make informed decisions based on current conditions, enabling them to fully enjoy their recreational activities with peace of mind. This makes the application a practical tool for families, solo travelers, adventure-seekers, and tourists alike, who can rely on it as a dependable source of environmental information. Consequently, this system not only serves as a valuable resource for beachgoers but also plays a role in advancing tourism management and coastal safety.

3.3 Architecture

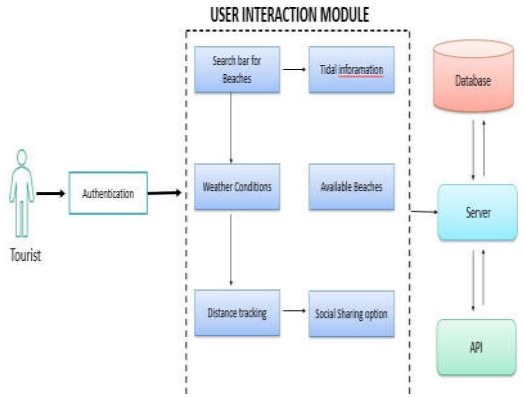


Fig. Architecture of Proposed system

The above diagram represents the system architecture of the application.

- **Tourist (User):**
  The tourist or user initiates the interaction with the app. This person is typically interested in accessing various beach-related information and services, like weather conditions, tidal information, and distance tracking.
- **Authentication:**
  Before accessing any beach information, the user must pass through the Authentication process. This step verifies the user's credentials, ensuring they are authorized to use the app. Once authenticated, the user can access the main features of the app through the User Interaction Module.
- **User Interaction Module:**
  This module acts as the primary interface for the user, providing access to various functionalities. Within this module, users can interact with different features:
  - Search Bar for Beaches: Allows users to search for specific beaches. The user can type in a beach name, and the system will fetch information related to that beach.
  - Tidal Information: Provides details about tides at selected beaches, helping users plan their visits based on tidal conditions.
  - Weather Conditions: Gives current weather updates for the selected beach, which is essential for user safety and planning.
  - Available Beaches: Displays a list of available beaches stored in the system, allowing users to browse and choose a destination.
  - Distance Tracking: Calculates the distance between the user's current location and the selected beach, enabling users to assess travel feasibility.
  - Social Sharing Option: Allows users to share beach information on social media platforms, promoting the app and sharing useful information with friends.
- **Database:**
  The Database stores essential data, including user information, beach data, and other static information required by the app. When the User Interaction Module needs data (e.g., beach details or available beaches), it sends a request to the Database. The Database retrieves and sends back the relevant information for display in the app.
- **Server:**
  The Server acts as the middle layer between the User Interaction Module and Database/API. It handles requests from the User Interaction Module, fetching data from the Database when necessary. For real-time data (such as weather conditions or tidal information), the server forwards requests to an external API.
- **API:**
  The API provides real-time information like weather and tides, which the app does not store locally in its Database. The Server sends requests to the API to get this live data, and upon receiving the response, it

relays the data back to the User Interaction Module for display to the user.

Advantages

1. Users can access beach info, weather, tides, and distance in one place, making planning easier.
2. Integration with APIs ensures up-to-date weather and tidal data for safe beach trips.
3. Modular design allows easy expansion and addition of new features.
4. Authentication safeguards user data, enhancing privacy and security.
5. Sharing options promote app visibility and user engagement on social platforms.

Disadvantages

1. Requires constant internet connectivity for real-time notifications.
2. Without internet, users have limited or no access to the latest information, impacting usability.
3. Integrating multiple data sources and modules increases development complexity and time.

Application

1. **Tourism Enhancement:**
   The app can be used by tourism boards and local authorities to promote safe tourism by recommending beaches with favorable conditions for activities like swimming, surfing, or sunbathing, boosting coastal tourism.
2. **Environmental Monitoring:**
   The app can track water quality and other environmental conditions, providing insights into pollution levels and ecological health of beaches, supporting environmental agencies in monitoring and maintaining beach quality.
3. **Beach Event Planning:**
   Event planners organizing beach events such as festivals, surfing competitions, or beach weddings can use the app to choose the best beach with optimal conditions for the event.
4. **Public Awareness and Education:**
   The app can be used to raise awareness about beach safety and environmental conservation, educating the public about the risks of certain beach conditions and the importance of clean and safe coastal areas.

4. SYSTEM DESIGN

4.1 Data Flow Diagram

What is a Data Flow Diagram (DFD)?

A Data Flow Diagram (DFD) is a visual tool used to depict how data flows through a system. It shows the movement of information, highlighting how input data transforms into output. DFDs help in understanding how data is processed and communicated within the system. There are typically two levels of DFDs:

DFD0

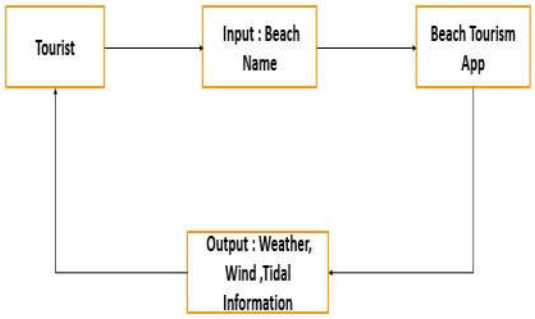
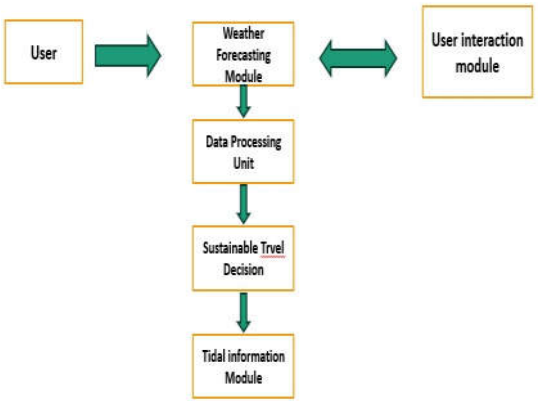


Fig. DFD0

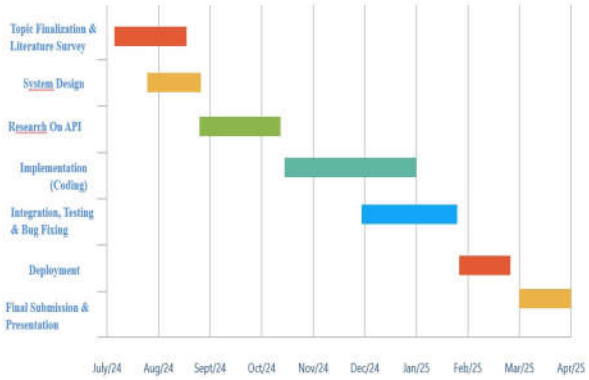
DFD1



Fig, DFD1

- Level 0 DFD (Context Diagram): This gives an overview of the system, showing the system as a single process with its inputs and outputs. It focuses on external entities interacting with the system.
- Level 1 DFD: This level breaks down the main process from Level 0 into smaller sub-processes, providing a more detailed view of how data flows internally within the system. A Data Flow Diagram (DFD) is a graphical tool used to depict the flow of data through a system, illustrating how input data is transformed into output through various processes. In the case of the beach tourism system, the Level 0 DFD provides a high-level view, showing how users interact with the app and the main data flow involved. It includes the following components: the Tourist (end-user) who inputs a Beach Name into the system, the Beach Tourism App which processes this input, and the Output (weather, wind, and tidal information) that helps the tourist make an informed decision about beach visits. The application flow here is straightforward: the tourist enters a beach name, the app processes this and retrieves relevant data, then displays the weather, wind, and tidal information. This Level 0 DFD offers a simplified overview of the data exchange between the user and the app.

4.2 MONTH WISE PLAN



4.3 Pre-test diagnosis

To assess the availability of beaches and enhance tourist satisfaction through our mobile application, we established key features for evaluating the weather conditions that impact beach accessibility. The input variables used to predict beach availability are as follows:

1. Input Variables (Features)

The input variables used to evaluate beach availability are denoted as: X=[B,T,H,R,W,P] where:

- B = Beach Name (Encoded)
- T = Air Temperature (°C)
- H= Humidity (%)
- R = Rain Intensity (mm)
- W = Wind Speed (m/s)
- P = Barometric Pressure (hPa)

2. Rule-Based Conditions for Availability

The availability of a beach is determined by a set of conditions based on weather parameters. The rule-based conditions for availability A are defined as follows:

A=1 if $20 \leq T \leq 35$, $H < 80$, $R < 2$, $W < 10$, $1000 \leq P \leq 1025$

{

0 otherwise

Here, A=1 indicates the beach is available, and A=0 indicates it is not available, based on the specified weather conditions.

3. Machine Learning Model:

Trained Random Forest Classifier

To predict beach availability, we trained a Random Forest Classifier model using the above features. The model is defined as:

A= f (B,T,H,R,W,P) where:

f is the prediction function learned from training data.

A represents the predicted availability of the beach, based on weather conditions.

The Random Forest Classifier predicts whether a beach is available (1) or not available (0) based on the input features.

4. Forecasting Future Availability

The model also enables forecasting future beach availability based on weather forecasts. For future weather data, the availability of a beach is predicted as follows:

1 if Beach is Available

A= {

0 if Beach is Not Available

This prediction allows users to check the availability of beaches in real-time, helping them make informed decisions about their beach visits.

5. RESULTS AND DISCUSSION

The application offers a smooth and user-friendly experience for individuals looking to explore and discover beaches. With an intuitive interface, users can effortlessly navigate through different features and find relevant information. The "Search Beach" functionality simplifies the process of finding specific beaches, making it convenient for users to look up destinations based on their interests and preferences. This feature eliminates the need for extensive manual searching, ensuring that users can quickly access details about various beach locations.

The graph in Fig. 2 illustrates a comparison between actual oceanic conditions and the forecasts generated by the developed application for Juhu Beach. Two critical environmental factors, wave height (measured in meters) and water temperature (in °C), are analyzed.

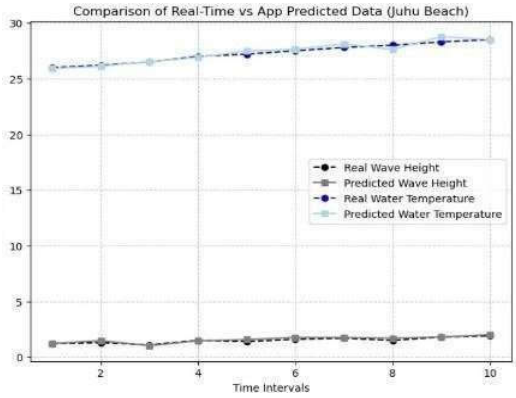


Fig. Accuracy of Predicted vs Real-Time Beach Weather Data

Real-time data, sourced from oceanographic observations, is depicted using dashed lines, while the application's predicted values are shown as solid lines. Wave height is represented in black and grey, whereas water temperature is visualized in blue and light blue.

The results reveal a strong correlation between the actual and forecasted values, with only slight discrepancies. This suggests that the application's predictive model accurately estimates real- time beach conditions with a high level of precision. Minor variations are likely due to natural fluctuations in oceanic and atmospheric conditions, which are inherently dynamic. Overall, these findings confirm the application's reliability in delivering near-accurate

environmental assessments, making it a valuable tool for coastal monitoring and recreational planning One of the most notable features of the application is its interactive map on the home screen, which provides a visual representation of beach locations using Google Maps integration. This allows users to explore beaches based on their geographic location, making it easier to plan trips and navigate to their chosen destination. The use of real-time mapping enhances the overall experience, offering accurate and up- todate information about beach locations. With just a few taps, users can identify nearby beaches, check their locations, and get directions seamlessly.

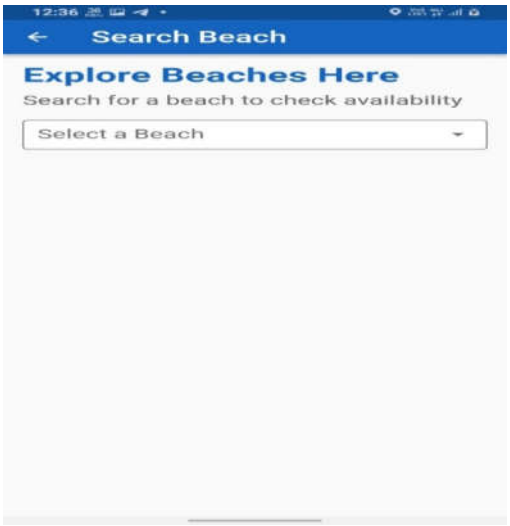
By eliminating the time-consuming nature of manual searches, the application fosters a more efficient and streamlined experience, ultimately making the process of discovering new beach destinations much more enjoyable. This smooth and user-centric approach encourages more people to explore beaches with confidence, knowing they can easily access all the necessary details at their fingertips. Furthermore, the app enhances the overall beach travel experience by providing real- time information, helping users make well-informed choices about their trips.

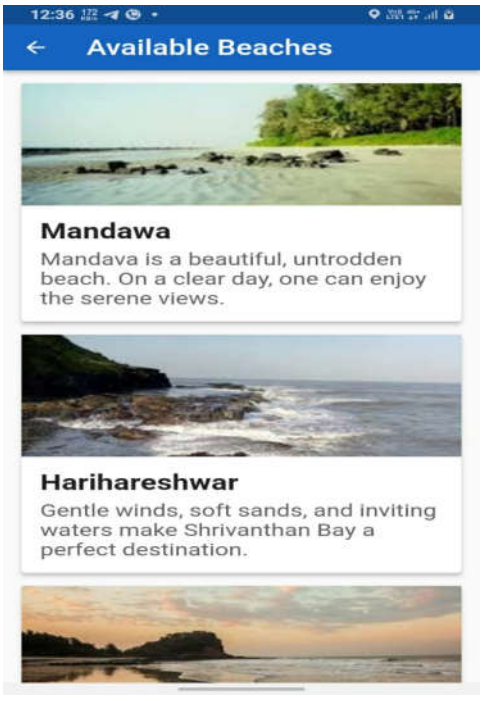
Fig. Projected Beach Suitability Over the Next 5 Day (Kovalam Beach)

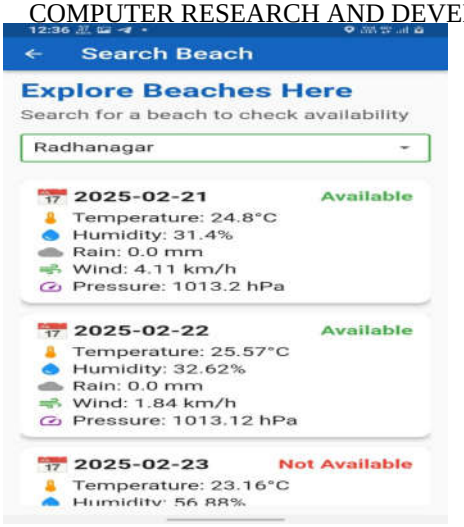
The bar chart presented in Figure 3 illustrates the projected beach suitability at Kovalam Beach over the next five days based on weather conditions. The suitability score, ranging from 0 to 10, is derived from key meteorological factors such as temperature, humidity, wind speed, and precipitation probability.

The data indicates that beach suitability fluctuates over the forecast period. Today, the suitability score is relatively high at 8, suggesting favorable conditions. However, a decline is observed tomorrow, with a score of 6, potentially due to mild adverse weather conditions. On Day 3, suitability reaches its peak at 9, indicating optimal beach conditions. Subsequently, suitability drops to 4 on Day 4, likely due to unfavorable weather changes, before slightly recovering to 7 on Day 5.

This analysis provides valuable insights for beachgoers, local authorities, and tourism operators, allowing for informed decision-making regarding beach visits and safety. The predictive model integrated into this study can be further refined by incorporating real-time weather updates and advanced machine learning techniques for improved accuracy.







6. CONCLUSION AND FUTURE SCOPE

In conclusion, this survey highlights the potential of using mobile technology to improve the beach tourism experience in India by providing real-time information on beach conditions, such as weather, water quality, and tides. With accurate and timely data, tourists can make safer and more enjoyable choices, supporting both responsible tourism and local businesses. This survey focus on enhancements, like machine learning for predictive safety alerts and future expanding to global beaches, could further strengthen this system. Ultimately, this approach promotes sustainable tourism while safeguarding coastal ecosystems and enhancing visitor experience. The development of a mobile application to provide beach suitability information across India offers significant promise for future enhancements. By integrating machine learning, the app could advance to predict beach conditions and visitor trends using historical data. This would boost safety measures by providing early alerts for risks like strong currents or hazardous marine wildlife. Expanding its scope, the app could eventually cover international beaches, functioning as a global beach safety resource. the app could promote eco-friendly tourism by highlighting beaches with sustainable practices, aligning with the increasing focus on responsible travel. Additionally, data gathered by the app could support local authorities in enhancing beach facilities, such as optimizing lifeguard presence. Integrating with smart wearables could deliver instant alerts for sudden dangers, providing realtime notifications directly to users on-site. The app's community features could be enhanced by allowing users to share live updates, photos, and experiences, offering that benefit others. Support for multiple languages and an intuitive interface would broaden accessibility for diverse users. The app could also give real-time suggestions for activities like surfing or snorkeling, helping users choose beaches based on current conditions. Collaborations with travel and tourism companies could add value by offering accommodation bookings and transport options, helping users plan visits around ideal beach conditions. The app could also serve coastal research, aiding studies on climate change, coastal erosion, and marine ecosystems. Including an offline mode would further support its use in remote areas with limited connectivity, ensuring users.

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