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Behavioral Mapping as a Basis for the Revitalization Concept of Public Space in the Ampenan Beach Area, Mataram City

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Abstract

Physical and tourism-oriented considerations often dominate revitalization projects in historic physical coastal public spaces, while the understanding of users' spatial behavior remains insufficiently integrated into the design process. This condition risks producing public spaces that are less responsive to local communities' needs. This study aims to map community behavior to inform the development of a revitalization concept for public spaces in the Ampenan Beach area of Mataram City. A qualitative-descriptive approach was employed through behavioral mapping methods grounded in temporal and spatial observations, supported by visual documentation and archival research. Data analysis identified patterns of activity, spatial use intensity, and the interrelations between user behavior and the site's physical setting. The findings reveal concentrations of informal activities, temporal variations in spatial utilization, and discrepancies between existing spatial design and users' actual behaviors. These results suggest that behavioral mapping functions not only as an observational tool but also as a conceptual framework for formulating context-sensitive, inclusive, and community-oriented principles of public space revitalization within historic coastal environments. This study is limited by a relatively short observation period and the absence of GIS-based spatio-temporal analysis; therefore, more comprehensive follow-up studies are required to strengthen the findings.

Keywords: Ampenan Beach, Behavioral Mapping, Public Space, Revitalization Concept

Pemetaan Perilaku Masyarakat sebagai Dasar Konsep Revitalisasi Ruang Publik Di Kawasan Pantai Ampenan, Kota Mataram

Abstrak

Revitalisasi ruang publik pesisir bersejarah seringkali hanya didominasi aspek fisik dan pariwisata, sementara pemahaman terhadap perilaku pengguna ruang masih kurang terintegrasi dalam proses perancangan. Kondisi ini berisiko menghasilkan ruang publik yang kurang responsif terhadap kebutuhan komunitas lokal. Penelitian ini bertujuan untuk memetakan perilaku masyarakat sebagai dasar perumusan konsep revitalisasi ruang publik di Kawasan Pantai Ampenan, Kota Mataram. Pendekatan kualitatif-deskriptif digunakan melalui metode behavioral mapping berbasis observasi temporal dan spasial, didukung oleh dokumentasi visual dan kajian arsip. Analisis data dilakukan dengan mengidentifikasi pola aktivitas, intensitas penggunaan ruang, serta hubungan antara perilaku dan latar fisik kawasan. Hasil penelitian menunjukkan adanya konsentrasi aktivitas informal, perbedaan pola pemanfaatan ruang berdasarkan waktu, serta ketidaksesuaian antara desain ruang eksisting dan perilaku aktual pengguna. Temuan ini mengindikasikan bahwa pemetaan perilaku tidak hanya berfungsi sebagai alat observasi, tetapi sebagai perangkat konseptual untuk merumuskan prinsip revitalisasi ruang publik yang lebih kontekstual, inklusif, dan berorientasi pada kesejahteraan komunitas lokal di kawasan pesisir bersejarah. Penelitian ini memiliki keterbatasan pada periode observasi yang relatif singkat serta belum mengintegrasikan analisis spasial-temporal berbasis GIS, sehingga diperlukan studi lanjutan yang lebih komprehensif untuk memperkuat temuan.

***Kata-kunci**: Konsep Revitalisasi, Pantai Ampenan, Pemetaan Perilaku, Ruang Publik*

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Introduction

The Ampenan Coastal area in Mataram City has a long history as a major port and intercultural transit point during the colonial era [1]. Although its function has shifted, this area remains an active public space accommodating social and economic activities. However, the use of this space is often not comprehensively planned, including activities such as informal trade, family recreation, and community interaction. As a result, utilization occurs without maximum attention to historical aspects, sustainability, and the quality of the space. This situation presents a revitalization challenge that is oriented not only toward physical development but also toward strengthening regional identity and community well-being [2], [3], [4].

The revitalization of urban public spaces, particularly in historic coastal areas, is receiving increasing attention due to the pressures of climate change and demands for improved quality of life for urban residents. Waterfront areas are understood not only as physical city assets, but as social and ecological spaces with identities [5], [6], [7]. Various studies confirm that the success of coastal public spaces is largely determined by their suitability for user activity patterns and needs, rather than solely by the quality of physical design [8], [9].

In this context, behavioral mapping is a strategic approach for understanding the relationship between humans and space. This method allows for the identification of activity patterns, intensity of space use, and the relationship between user behavior and the physical characteristics of the environment [10], [11]. As it develops, this approach also has the potential to be integrated with technologies such as Geographic Information Systems (GIS) to strengthen spatial-temporal analysis in further research [12], [13]. However, in coastal planning and revitalization, behavioral data is often underutilized. Many studies and revitalization projects still separate socio-spatial analysis from the formulation of design concepts, resulting in a normative, less contextual approach [14], [15], [16]. In Indonesia, studies on the use of coastal public spaces generally focus on the physical or economic aspects of tourism. At the same time, community behavior patterns and spatial preferences of various user groups remain little discussed [17], [18].

A similar situation is evident in the Ampenan Coastal Area. The pressures of tourism-based revitalization and economic development have the potential to shift the area's social function if not supported by a comprehensive understanding of user behavior [19]. The lack of integration of behavioral data in planning risks produces less inclusive and unsustainable public spaces.

Based on this gap, this study proposes community behavior mapping as a conceptual basis for revitalizing public spaces in historic coastal areas. The research objective is to identify spatial behavior patterns of residents in the Ampenan Coastal Area and analyze their implications for formulating a public space revitalization concept that focuses on users and the well-being of local communities.

Methods

This research is within the post-positivist paradigm, using a qualitative-descriptive approach that views human behavior and space as contextual phenomena that can be understood through systematic observation and spatial interpretation [20]. The research is descriptive-exploratory, aiming to reveal patterns in the utilization of coastal public spaces and their relationship to the area's physical context. The approach used is a case study [21], [22], with the Ampenan Coastal Area in Mataram City, West Nusa Tenggara Province, as the location (Figs. 1 and 2), given its status as a historic coastal area actively used by various community groups.

Figure 1. Research location, Ampenan Beach, Mataram City, West Nusa Tenggara

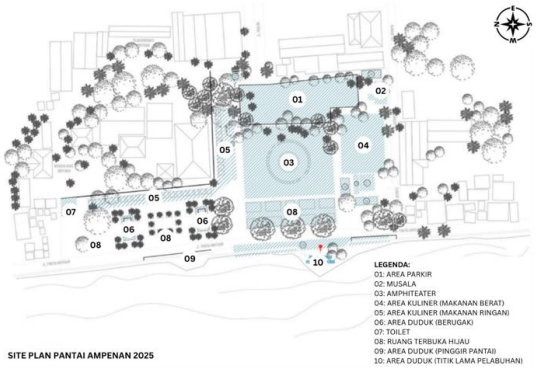


Figure 2. Site plan of Ampenan Beach

Theoretical Framework for Behavioral Mapping

Behavioral mapping in this study draws on an environmental psychology approach that emphasizes the reciprocal relationship between individuals and their physical settings [23], [24]. This method is used to systematically record the types of activities, their locations, and their spatial distribution patterns over a specific time period. As it develops, behavioral mapping serves not only as a tool for documenting activities but also as an analytical instrument for identifying relationships among spatial configuration, environmental affordances, and user preferences. This framework enables contextual spatial interpretation, particularly for understanding how coastal public spaces are interpreted and used by the community.

Data Collection Methods

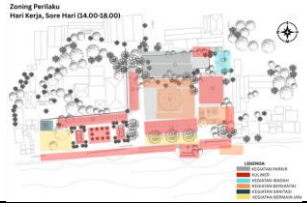
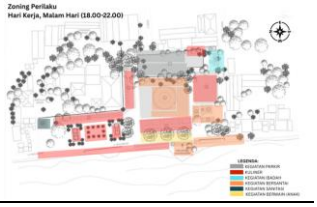
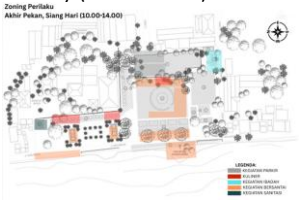
Data collection was conducted using three main methods: (1) Direct observation based on behavioral mapping, recording activity, intensity, and location at different times (morning, afternoon, evening, and night). (2) Visual documentation, in the form of photographs and area maps, to record the physical setting and spatial conditions that influence user behavior. (3) Archival studies, including historical maps and literature related to the development of the Ampenan area.

Observations were conducted over 10 days, spanning weekdays and weekends, to capture temporal variations in activity. Table 1 shows that each observation day was divided into four time periods (morning: 7.00-10.00, midday: 10.00-14.00, afternoon: 12.00-18.00, evening: 18.00-22.00), resulting in a total of 40 observation sessions. Observations were conducted throughout the Ampenan Beach area. At each session, the number of activity occurrences was recorded by behavioral category and location.

Space users were grouped by activity type and space-use characteristics, without any sensitive demographic classifications. This research was conducted entirely in a public space without intervention from the subjects. In addition to observations, brief interviews were conducted with several space users and local participants in activities to understand the area's historical value and the meaning embedded in daily practices. No personal data collection, in-depth private interviews, or documentation identifying specific individuals were conducted. Therefore, this research adhered to the ethical principles of research in public spaces, namely anonymity, non-intrusiveness, non-interference with the natural behavior of space users, and voluntary participation without recording respondents' identities.

As a method based on direct observation, this research is susceptible to observer bias in recording and interpreting activities. To minimize this bias, recording was conducted using a structured observation sheet and visual documentation to cross-check. Furthermore, the temporal limitations may not fully represent seasonal dynamics or special events. Therefore, the results of this study are interpreted within a limited observation time frame, and further longitudinal studies are recommended to strengthen the generalizability of the findings.

Table 1. Mapping of Ampenan Beach User Behavior on Weekdays and Weekends

Weekdays			
Morning (07.00-10.00)	Midday (10.00-14.00)	Afternoon (14.00-18.00)	Evening (18.00-22.00)
			
Weekends			
Morning (07.00-10.00)	Midday (10.00-14.00)	Afternoon (14.00-18.00)	Evening (18.00-22.00)
			

Data Analysis Method

Data analysis was conducted using qualitative behavioral mapping analysis, with the following stages: (1) grouping activity types and locations, (2) identifying spatial and temporal patterns of space use, and (3) interpreting the relationships between behavior, the physical setting, and the historical value of the area. The results of the analysis are presented as activity maps, tables of space-use intensity, and tables of behavior-space relationships. This approach allows for the development of knowledge that connects empirical behavioral data with public space design principles, as recommended in behavioral and place-making studies [25], [26], [27].

Results and Discussion

General Characteristics of Ampenan Beach Public Space User Behavior

Observations indicate that community activity at Ampenan Beach remains relatively stable between weekdays and weekends, with differences in intensity and peak times (Table 1). Morning activity is dominated by light exercise, food vendors preparing food, and children playing in the open area. The midday activity decreases, with visitors tending to relax in shaded areas or rest around the prayer room (*mushalla*). The afternoon and evening are the most active periods, characterized by dense parking, a predominance of culinary activities, and increased social interaction around the beachfront. Evening activity remains bustling in the culinary area, while informal vendors begin to decline.

Spatially, eight main behavioral categories were identified: (1) parking, (2) culinary, (3) relaxing, (4) children playing, (5) worship, (6) sports, (7) taking photos, and (8) fishing (Table 2). This pattern demonstrates the coexistence of formal and informal activities, as well as a shift in spatial function from planned to adaptive, for example, circulation paths and open spaces transforming into places for eating and gathering with mats (Fig. 4). These activities are communal and sedentary, particularly from the afternoon to the evening, demonstrating the community's tendency to negotiate spatial boundaries in response to social and economic needs.

Table 2. Area and Intensity of Space Use on Ampenan Beach

Area	Dominant Activity Type	Morning (07:00–10:00)	Midday (10:00–14:00)	Afternoon (14:00–18:00)	Evening (18:00–22:00)	Pattern Description
Parking Area	Parking, transit	Low	Low	**High**	**High**	Serves as the starting and ending point of mobility
Northern Culinary Area (Light Food Stalls)	Culinary, social interaction	Low	Medium	**Very High**	**High**	Peak activity occurs in the afternoon–evening
Southern Culinary Area (Food Court)	Culinary, social interaction	Low	Medium	**High**	**Medium**	Peak activity occurs in the afternoon–evening
Leisure Area	Relaxation, communal mat dining	Medium	Low	**Very High**	**High**	Adaptive use of open space and coastal edge as a socio-communal space
Children's Play Area	Children's play circulation, informal vending	Low	Low	**Very High**	**High**	Adaptive use of open space
Worship Area	Worship, relaxation	Low	**Medium**	**Medium**	Low	Dual function: religious and social
Sports / Sitting Area	Exercise, performances	**Medium (weekends)**	Low	**Medium**	Low	Potential community space
Photo Area	Photography, enjoying the view	**Medium**	Low	**Very High**	Low	Adaptive use of coastal edge as visual recreational space
Fishing Area	Fishing, enjoying the view	Low	Low	Low	Low	Adaptive use of coastal edge

Intensity Classification:

- Low = 1–9 occurrences per session
- Medium = 10–19 occurrences
- High = 20–29 occurrences
- Very High = ≥30 occurrences

Findings on the dominance of informal economic activity during the afternoon-to-evening timeframe indicate that waterfront public spaces tend to experience an intensification of socio-economic activity during the day-to-night transition period [13]. This pattern demonstrates that the vitality of coastal public spaces is determined not only by formal design but also by users' temporal adaptation to climatic and social conditions. However, unlike the aforementioned study, which found formal-informal integration through planned zoning, the expansion of activities at Ampenan Beach occurs spontaneously and extends beyond the existing design boundaries. This indicates a gap between spatial configuration and actual user needs.

These findings suggest that behavioral maps can reveal how public space is produced through user actions and habits, not just through its formal design [10]. Informal activities at Ampenan Beach, such as expanding into open areas and along circulation paths using mats, do not reflect design failures but rather adaptive responses to the needs of social space that is not formally accommodated. Goličnik and Nikšič [12] explain that the success of a public space is measured not by its conformity to the plan, but by its ability to support diverse and dynamic activity patterns.

Thus, user behavior at Ampenan demonstrates that the beach's public space functions as an arena for social practice, where the logic of space is determined by use rather than by the design of its built environment [25]. The sedentary, communal activities that dominate in the afternoons demonstrate the need for flexible spaces with a strong social function, while also opening opportunities to guide revitalization design based on user experience rather than just visual aesthetics.

Spatial and Temporal Patterns of Public Space Utilization at Ampenan Beach

The activity mapping in Tables 1 and 2 shows three main categories of space in the Ampenan Beach area: (1) Dense zone: culinary area, open area, and beachfront, with the highest intensity in the afternoon and evening, (2) Quiet but designed zone: the southern parking area and open areas without shade, with low activity levels outside of peak hours, and (3) Spontaneous zone (undesigned but active): pedestrian paths and open areas used for communal dining or children's play during peak hours.

Furthermore, changes in spatial function were also found, with a high number of sports and family activities in the morning, fewer activities during midday, and a more passive approach, and the afternoon and evening dominated by social, culinary, and recreational functions. This spatial-temporal analysis demonstrates a relationship between spatial configuration and user behavior [13]. Public beach space in Ampenan exhibits time-activity polarization, in which function and intensity shift with the community's use over time. This phenomenon reinforces the concept of temporal zoning in the study of coastal public spaces, which emphasizes that zoning should consider time of use, not just functional type.

The culinary area on Ampenan Beach is defined by two main areas: a food court housing main-dish vendors and a food-stall area dominated by snack and beverage vendors (Fig. 3). Functionally, these two points were originally designed solely as sales areas, without a clearly defined dining area. However, in practice, visitors tend to expand the consumption zone into open areas, the beachfront, and even spaces not formally designated for dining, such as the *berugak* (gazebo) that originally served as a public relaxation area (Figs. 4 and 5).

Figure 3. Food stall (left) and food court (right).

Figure 4. Expansion of the culinary area towards the open area and circulation path.

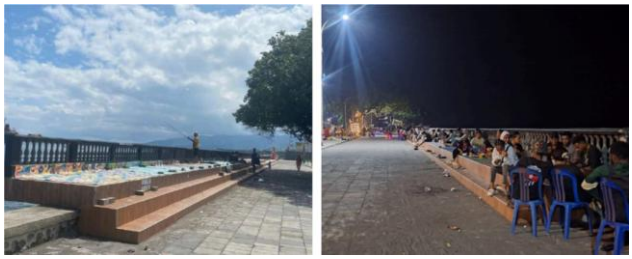


Figure 5. Comparison of beach area use during the day and at night.

This expansion pattern reflects users' territorial expansion, where the boundaries between commercial and public spaces are blurred. This

phenomenon demonstrates that culinary activities play a major role in generating spatial density, while also highlighting the limitations of design in accommodating users' socio-economic needs.

The presence of illegal parking adjacent to the culinary zone also demonstrates a strong functional relationship between vehicle mobility and economic activity (Fig. 6). Parking areas are often used not only as parking spaces for vehicles but also as loading and unloading points for food and merchandise, particularly during the afternoon preparation hours. This situation indicates the need for a more planned service or loading area integrated with the vendors' operational areas to avoid circulation conflicts with visitors.

Figure 6. Expansion of the parking area approaching the food court area.

In addition to the expansion in the culinary zone, activity expansion also occurs in open areas and the beachfront zone, where children's game vendors and informal, spontaneous play areas have emerged (Fig. 7). These spaces become magnets for family activity from the afternoon to evening, indicating the high spatial dynamics of coastal areas. The buying and selling of toys and children's use of play areas demonstrate the adaptive and temporary character of public spaces, where actual social practices often transcend the boundaries of formally planned functions.

Figure 7. Expansion of the children's toy sales area towards the pedestrian path.

The spontaneous activity patterns in open and pedestrian areas also reflect social cohesion through shared space, where physical space becomes a catalyst for community encounters [7]. Meanwhile, the tension between "designed" spaces (stalls) and "practiced" spaces (such as informal dining areas) demonstrates that conventional revitalization approaches remain weak in interpreting user behavior. The mismatch between design and actual practice is not the user's fault but indicates that the applied design approach is not fully contextual to the local space [26].

Figure 8 illustrates the dynamic relationship between space types, temporal variations, and user behavior in shaping public space utilization patterns at Ampenan Beach. Three primary spatial categories: dense zones, quiet but designed zones, and spontaneous zones, interact with daily time variations (morning, midday, afternoon, and evening), resulting in distinct patterns of use. These temporal shifts influence user behavior, which is characterized by expansive use, territorial practices, and predominantly sedentary and communal activities.

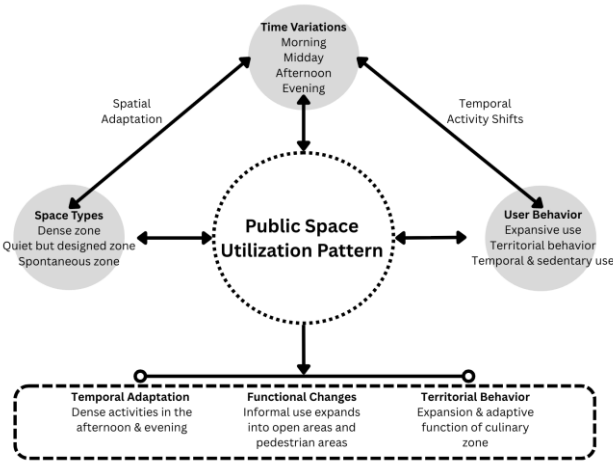


Figure 8. Public Space Utilization Pattern.

This reciprocal interaction produces a central pattern of public space utilization, where space is not statically defined by design but continuously reshaped through everyday practices. The lower section of the diagram highlights key implications of this relationship, including temporal adaptation (peak activity in the afternoon and evening), functional transformation (informal expansion into open and circulation spaces), and territorial behavior (adaptive use of culinary zones), emphasizing that spatial configuration and actual uses are co-constructed through time-based social practices.

Behavior, Historical Value, and Dynamics of the Ampenan Coastal Area

Interviews and field observations indicate that several objects, such as the former Bank Indonesia building, warehouses, and the remains of the old pier structure,

are iconic elements recognized by the local community as historical relics (Fig. 9 and 10). However, these elements have not yet fully become centers of social activity, and many have even experienced physical decline. Economic and recreational activities tend to be centered around the culinary and beachfront areas, while the historical area around Pabean Street remains relatively underutilized except as a backdrop for photographs. Some residents associate these locations with collective memories of the port's glory and past cultural activities, but these historical values have not been actively integrated into community activities.

Figure 9. Bank Indonesia building in the early 19th century (left) and in 2025 (right). The building appears to be obscured by food stalls.

Figure 10. Ampenan Pier when it was still operational (left) and the remains of the pier's pillar structure (right).

These findings suggest that historical values in Ampenan currently serve more as a passive backdrop than a catalyst for social activity. Coastal revitalization projects often face a conflict between physical conservation and the social life of the local community [14]. However, balancing economic and community interests is crucial to ensure that revitalization does not simply objectify history [19]. In the context of Ampenan, preservation strategies focused on building conservation are insufficient to revitalize spaces, as historical values do not automatically come to life through physical forms but rather through their integration with everyday social practices.

Therefore, Ampenan revitalization needs to be directed toward an interpretive heritage approach [10], which combines historical memory with contemporary community activities through educational activities, cultural festivals, and community-based creative spaces. This approach allows historical values to transform into living identities, rather than isolated visual artifacts.

Implications of Behavioral Mapping for the Ampenan Beach Public Space Revitalization Concept

Compared with the physical conservation-based revitalization approach discussed by Nasruddin et al. [14], this study's results indicate that strengthening the identity of historic coastal areas requires integrating everyday social practices into design strategies. Consistent with Linh and Son [19], community-oriented revitalization has proven more sustainable than tourism-based approaches alone. In this context, behavioral mapping serves as a conceptual tool to bridge historical values and modern social dynamics.

The integration of the results indicates that community behavior at Ampenan Beach forms three main patterns: the dominance of social-communal activities in the evening and at night (especially in the culinary and open space zones), the formation of adaptive informal spaces (such as pedestrian areas and open areas with changing functions), and the imbalance between designed and practiced spaces (indicating the need for a flexible and time-based design approach). Spatial conflicts arise from the overlapping functions of vendors and visitors. At the same time, design opportunities are evident in the high level of community participation and a sense of belonging to the area. Behavioral mapping in Ampenan serves not only as an observational tool, but also as a conceptual tool for formulating design principles for coastal public spaces. The results of behavioral mapping can be translated into behavior-informed design strategies, where design is guided by actual usage patterns [27].

From the data synthesis, three main conceptual principles emerged for the revitalization of Ampenan Beach:
1. Spatial flexibility, allowing for changes in function over time.
2. Strengthening informal spaces, recognizing the existence of non-formal activities as a legitimate part of social dynamics.
3. Time-based zoning, replacing static functional divisions with temporal configurations.

Good public spaces not only support behavior but also grow from it [10]. This principle emphasizes that behavior-based revitalization is more inclusive of local spatial culture and can improve users' social and ecological well-being.

Specific Design Recommendations

Based on the behavioral mapping and behavior-space relationship table, the implications for the revitalization of Ampenan Beach can be formulated into several strategic categories that link dominant activity patterns with contextual spatial interventions (Table 3).

First, the implementation of time-based zoning in the culinary area and open space, where the layout of stalls, seating areas, and pedestrian circulation is adjusted to peak afternoon and evening activity without disrupting the morning recreational function. This strategy can be implemented through modular elements and flexible, easily moved furniture.

Second, the integration of the culinary service area by providing loading and unloading lanes and preparation areas separate from the main pedestrian path. This arrangement aims to reduce spatial conflicts among vehicles, vendors, and visitors while maintaining the area's comfort and safety.

Third, the strengthening of communal and informal spaces. Open spaces and the beachfront, used for relaxation, children's play, and social interaction, demonstrate a high level of informal space adaptation. Revitalization needs to accommodate this by providing shading elements (natural or artificial canopies), seating, night lighting, and integrated sanitation infrastructure. For the children's play area, development is underway in the form of a thematic playground.

Fourth, strengthening connectivity and recreational activities. Sports and leisurely walking activities along the promenade require strengthening, with clearer, safer jogging and cycling paths connecting to the amphitheater as a community space.

Fifth, optimizing the promenade as an interpretive heritage path. The distribution of photography and fishing activities along the coastal corridor demonstrates the promenade's strong potential as a visual recreation space and regional identity. Strengthening signage based on local history, thematic vantage points, and reconstructing a lightweight pier as a multifunctional space (fishing and photography) can enhance the quality of the spatial experience while strengthening the heritage narrative.

With this approach, behavioral mapping not only generates conceptual principles but also translates

Table 3. Behavior, Spatial Interactions, and Design Implications for Revitalization

Behavior Type	Dominant Space	Activity Characteristics	Peak Time	Spatial Connectivity (Spatial Interaction)	Design / Revitalization Implications
Parking	North–west parking area (near main entrance)	Stationary	Midday–Afternoon	Functions as the main gateway connecting culinary zones, open spaces, and promenade	Requires centralized parking management and designated loading/unloading areas to support culinary operations
Culinary	Open space (mat seating), beachfront (mat seating), food stalls, and food court	Stationary – Communal – Economic	Afternoon–Evening	Connected to parking areas, promenade, and open spaces	Requires integration of dining areas and circulation paths to minimize spatial conflicts
Leisure	Open spaces, beachfront	Stationary – Communal	Midday–Afternoon	Located adjacent to culinary areas	Requires shaded areas, seating, lighting, and natural or artificial canopies
Children's Play	Open spaces, pedestrian paths, beach	Mobile – Communal	Morning–Afternoon	Located near leisure and culinary areas	Requires thematic playgrounds and improved child-friendly safety in circulation paths
Worship	*Mushalla* (prayer space)	Stationary – Individual–Social	Midday–Evening	Acts as a central node within circulation	Requires optimization of dual functions (religious and community use)
Sports	Open spaces, amphitheater	Mobile – Communal	Morning (weekends)	Connected to promenade and cycling paths	Strengthen connectivity of active mobility routes (jogging and cycling)
Photography	Promenade, colonial buildings, heritage walk	Mobile – Individual	Afternoon–Evening	Distributed along the coastal corridor	Requires identity-based signage and thematic photo spots
Fishing	Beachfront	Stationary – Individual	Afternoon–Evening	Located on the western edge of the area	Requires pier reconstruction as a fishing and photo spot, along with safety measures and adequate lighting

them into structured, adaptive design intervention categories based on the actual spatial practices of the Ampenan Coast community.

Conclusion

This study found that community behavior on Ampenan Beach creates a dynamic public space structure in which formal and informal spaces interact and change over time. Evening and night communal activities highlight the importance of social and temporal dimensions in the design of coastal public spaces.

The scientific contribution of this study lies in utilizing behavioral mapping not merely as an observational tool, but as an architectural conceptual tool for formulating revitalization strategies based on user behavior. Practically, these results provide a foundation for more adaptive and participatory public space design.

This study is limited by its relatively short observation period and the lack of in-depth quantitative spatial-temporal data. Furthermore, this study did not integrate Geographic Information Systems (GIS)-based analysis, resulting in a qualitative-descriptive behavioral mapping approach. Therefore, the development of geographic information systems-based behavioral mapping and longitudinal studies with longer time spans represents opportunities for further research to improve analytical precision and generalize the findings.

AI Use Declaration

The authors acknowledge the use of ChatGPT (GPT-5.3, OpenAI) as a supporting tool for language-related assistance, including translation, grammar checking, and improving clarity and academic tone. The outputs were used solely to refine sentence structure and readability and were critically reviewed and revised by the authors. No AI tools were used to generate research content, analyze data, interpret results, or draw conclusions. The authors take full responsibility for the content of this manuscript in accordance with COPE guidelines and journal policies.

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