

Aligning Facility Mix with User Demographics in Former Industrial Waterfront Piers: An Exploratory Comparison of Four North American Cases with Implications for Busan North Port

Htet Won Yan

Pusan National University

Keojin Jin

keojin.jin@pusan.ac.kr

Pusan National University

Research Article

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Posted Date: October 22nd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11285682/v1>

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Additional Declarations: No competing interests reported.

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Abstract

As maritime industries decline, many waterfront piers have become underutilized. Existing scholarship addresses spatial configuration, governance, and sustainability but says little about how the demographic characteristics of surrounding populations should inform facility programming in revitalized piers. This paper examines that relationship through an exploratory comparison of four former industrial piers: Pier 17 and Pier 57 (New York), Pier 57 (Seattle), and Pier 39 (San Francisco). For each case, a 15-minute pedestrian catchment — the census tracts within 1.2 km of the pier entrance — was profiled from American Community Survey 2019–2023 tract estimates by age, household income, and occupation, and the facility mix was measured as shares of programmable floor area across table-service dining, counter-service dining, retail, and recreation. Facility mix corresponds less with income — all four catchments are affluent, and the two most affluent have the most and the least dining-led programs — than with age structure and visitor orientation: older, multi-generational catchments coincide with larger recreational and public-space shares, young working-age catchments with dining-led programs, and a tourist-dominated visitor base with substantial retail. Where a catchment is polarized, as at Pier 17, programming follows the dominant spending segment and under-serves adjoining lower-income residents. Because each pier also holds a distinctive landmark asset, these are exploratory patterns, translated here into planning implications for Busan North Port, Korea, whose adjoining districts are among the oldest and lowest-income in the city, pointing toward a balanced mix with explicit provision for existing residents rather than a premium dining-led one.

Keywords: waterfront revitalization, demographic analysis, facility programming, multi-functional pier, Busan North Port

1. INTRODUCTION

Since the late twentieth century, shifts in maritime logistics, port restructuring, and changing port-city relationships have displaced many working waterfront functions away from historic inner-city edges, leaving extensive waterfront land and infrastructure underused or re-purposed (Hoyle 1989; Tommarchi 2025). Recent scholarship argues that the older ‘port out, city in’ narrative is no longer sufficient to describe contemporary waterfront redevelopment, because approaches now range from consumption-oriented redevelopment driven by global capital to more fine-grained, sustainability-oriented strategies that attempt to re-integrate compatible port-related activities into mixed-use districts (Avni and Teschner 2019; Tommarchi 2025). Global waterfront cities are entering a second wave of post-industrial regeneration. The first wave, exemplified by Baltimore's Inner Harbor (1980s) and Sydney's Darling Harbour (1980s–1990s), demonstrated that transforming derelict port zones into mixed-use public destinations could generate substantial economic and social returns (Marshall 2001). A second wave, now underway in Asian cities including Busan, Kobe, and Singapore, confronts more complex planning conditions: aging populations, declining commercial rents, increased competition from online retail, and heightened expectations for inclusive public space (Liu and Park 2025; Kim 2024).

Industrial waterfront revitalization research further emphasizes that post-industrial waterfronts typically require reinvention strategies that treat former industrial structures and landscapes not as blank sites for replacement but as adaptable assets capable of supporting new programs and public life (Ma et al. 2023; Tommarchi 2025). At the scale of everyday urban use, recent empirical work on waterfront vitality indicates that functional diversity and design quality related to pedestrian movement and proximity to water are among the most influential factors associated with increased waterfront public-space vitality (Fan et al. 2023). Despite this, the literature on waterfront revitalization has prioritized spatial configuration, governance, and environmental sustainability over systematic analysis of how the demographic and socioeconomic characteristics of surrounding communities influence appropriate facility programming (Avni and Teschner 2019; Uzumcuoglu and Polay 2023).

This paper addresses this gap through an exploratory comparative analysis of the relationship between user demographics and facility mix in four revitalized industrial piers, and translates the observed patterns into planning implications for early-stage facility programming. The four North American cases are used not because their demographic conditions resemble Busan's, but because they offer the methodological components — walkable catchment definition, facility classification, demographic–facility comparison — that this study argues are structurally transferable even where the underlying demographic composition is not. Busan's North Port serves as the motivating planning problem that defines why such a transferable procedure is needed, rather than as a site where the specific demographic–facility correspondences found in this study (e.g., high-income catchments favoring fine dining) are expected to hold unmodified.

The study therefore proposes a transferable demographic profiling procedure that links program mix to catchment-level user-context profiling and facility-proportion patterns. The scope is intentionally limited to an early-stage design decision tool concerned with what program types to emphasize. Where facilities should be placed within the pier structure — the question of spatial configuration and circulation — is addressed in a companion study and is outside the scope of this paper, as are real-estate feasibility modeling and governance evaluation.

This study is guided by two research questions:

1. How do the demographic characteristics of the surrounding neighborhoods and facility proportion of the piers differ across the selected case studies?
2. How does facility mix vary in relation to the income level, age structure, and occupational profile of the catchment, and to the pier's visitor orientation?

Visitor orientation — the extent to which a pier's users come from beyond its resident catchment — is characterized with publicly available online visibility indicators (Google Maps review volume, Instagram post counts, and Google Trends search interest), normalized by catchment population and by years since reopening (Section 4.2). These indicators describe the reach of each pier relative to its resident base; they are not treated as measures of facility performance or success.

The overall research process proceeds in four stages, as summarized in Fig. 1. The first stage establishes the theoretical and empirical foundation through a review of three bodies of literature: waterfront revitalization approaches, demographic catchment analysis methods, and hybrid waterfront planning theory. These three threads converge on a shared gap, namely the absence of a systematic method for linking catchment demographic profiles to pier facility programming decisions. The second stage addresses this gap through a comparative case study design. Four former industrial piers in North America — Pier 17 in New York, Pier 57 in New York, Pier 57 in Seattle, and Pier 39 in San Francisco — are selected on the basis of their post-industrial adaptive reuse, multi-facility commercial programming, and demographic data accessibility. For each pier, the 15-minute catchment is delineated and profiled across three variables: median household income, age structure, and occupational profile. Facility floor area is simultaneously mapped and classified into proportional categories covering table-service dining, counter-service dining, retail, and recreation. Each pier's visitor orientation is characterized from normalized online visibility indicators. The third stage compares these data sets to examine whether the demographic profile of each catchment and the pier's visitor orientation correspond to the observed facility mix. The fourth stage synthesizes the identified patterns into planning implications for second-wave Asian port-city revitalization, with Busan's North Port as the motivating application setting.

Research method

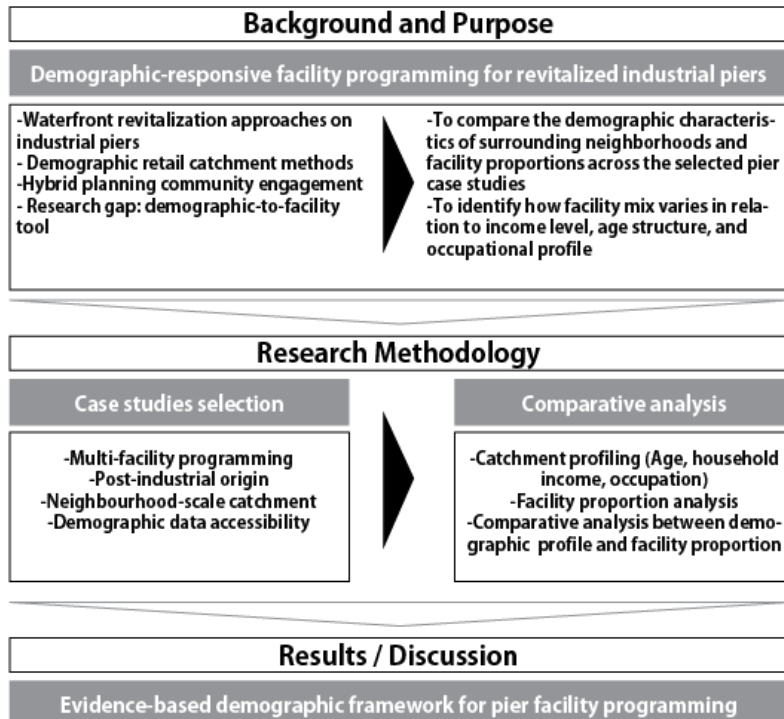


Fig. 1 Research method

2. LITERATURE REVIEW

This literature review establishes the theoretical basis for a demographic-responsive approach to facility programming in former industrial waterfront piers. It is organized around three bodies of scholarship. First, waterfront revitalization literature explains the shift from physically oriented redevelopment toward socially responsive, multifunctional, and publicly accessible waterfront planning. Second, commercial and recreational facility-planning literature demonstrates how demographic analysis can inform the selection and distribution of facility types. Third, hybrid waterfront planning theory frames demographic analysis as a practical instrument for incorporating community needs into early-stage programming decisions. Together, these fields reveal a methodological gap: although existing studies emphasize social sustainability, public use, and stakeholder integration in waterfront redevelopment, they rarely provide a replicable method for translating nearby demographic characteristics into facility-mix decisions within pier-specific adaptive reuse contexts.

2.1. Waterfront Revitalization: From Spatial to Social Approaches

Urban waterfront redevelopment has now passed the point where the basic storyline, industrial decline followed by public-oriented regeneration, can explain contemporary outcomes. Recent typological reviews show that present-day waterfront projects range from large-scale, consumption-driven ‘neoliberal’ redevelopment to more fine-grained strategies that attempt to reintegrate port-related activities and deliver environmental and social sustainability.

More recent scholarship has expanded this understanding by emphasizing social, cultural, environmental, and governance dimensions of waterfront redevelopment. Tommarchi (2025) shows that waterfront redevelopment has evolved through multiple typological phases rather than a single universal model, while Avni and Teschner (2019) identify recurring planning conflicts related to land ownership, heritage and culture, social and environmental justice, and resilience. Similarly, Evans et al. (2025) frame waterfront sustainability through ecological, cultural, social, economic, and political dimensions. These studies suggest that contemporary waterfront planning is no longer evaluated only through physical design quality or economic redevelopment value, but also through its capacity to support public accessibility, social inclusion, ecological resilience, cultural continuity, and long-term urban integration.

Multi-criteria waterfront studies further reinforce this shift by evaluating waterfront public spaces through physical quality, functional performance, social and economic factors, environmental quality, and governance conditions (Uzumcuoglu and Polay 2023, 2024). Research on waterfront vitality also shows that spatial elements, accessibility, activity distribution, and public-space configuration influence how waterfront areas are actually used (Fan et al. 2023). These studies are important because they move waterfront revitalization beyond a purely physical or image-based redevelopment model. However, former industrial piers require a more specific analytical focus. Unlike large waterfront districts or continuous promenades, piers are spatially constrained by linear geometry, limited access points, fixed structural footprints, and strong waterside exposure. A revitalized pier must not only attract visitors to its entrance or waterfront edge, but also sustain movement, activity, and dwelling across the depth of the pier structure. Therefore, the success of pier revitalization depends on more than general waterfront accessibility; it also requires careful alignment between spatial organization, facility mix, and user demand.

Existing waterfront studies provide valuable frameworks for understanding public access, mixed-use development, cultural reuse, social sustainability, and governance. However, many studies remain focused on waterfront districts, public spaces, governance processes, or broad redevelopment outcomes. Less attention has been given to how specific facility types should be selected and proportioned within former industrial pier structures. This limitation is significant because facility programming is one of the main mechanisms through which a revitalized pier becomes socially active, economically viable, and publicly relevant.

2.2. Demographic Analysis in Commercial and Recreational Facility Planning

Demographic analysis has long been a core tool in retail planning, where it serves to match facility type, price point, and tenant mix to the purchasing power and lifestyle preferences of the trade area population (Urban Land Institute 2008). Coleman (2006) identifies age, income, household size, and occupational category as important demographic variables in retail trade-area analysis, suggesting that these indicators can help estimate broad patterns of facility demand. In this practice literature, high-income professional populations are expected to generate demand for fine dining, branded retail, and experiential leisure; middle-income, mixed-age populations to support casual dining, family entertainment, and value retail; and income-diverse tourist destinations to require flexible programming that serves residents and transient visitors simultaneously (Coleman 2006; Urban Land Institute 2008). These expectations derive from shopping-center experience rather than from waterfront evidence, and Section 5 examines how far they hold for revitalized piers.

In commercial facility planning, catchment-based demographic analysis is particularly important. Retail centers, food markets, entertainment districts, and mixed-use developments are often planned in relation to the population that can access them within a defined walking, driving, or transit-based catchment. The demographic profile of this catchment helps planners

and developers interpret purchasing power, daily-use frequency, service demand, and potential facility preferences. For example, higher-income professional catchments may be associated with stronger support for table-service dining, branded retail, cultural amenities, and experience-oriented leisure. In contrast, income-diverse or tourism-oriented catchments may require a broader combination of counter-service dining, flexible retail, family-oriented entertainment, and affordable recreational facilities.

Recent studies have extended these principles to mixed-use and destination-oriented commercial environments. Chen, Xue, and Sun (2023) analyze American-style shopping malls in China through a database/mosaic approach, demonstrating how commercial facility development can be interpreted through urban context, scale, typology, and design characteristics. Pang and Sanders (2025) further show that shopping tourism and mixed-use shopping mall communities can generate place-based economic and experiential value through placemaking, dining, and leisure-oriented programming. These studies support the broader argument that facility mix should be understood not only as a design or leasing decision, but also as a response to user context, consumption patterns, and destination identity.

This logic is relevant to waterfront piers, but it has not been sufficiently adapted to pier-specific revitalization. Former industrial piers often function as hybrid destinations. They may serve nearby residents and workers during weekdays, tourists during weekends and holidays, and event-based visitors during specific seasons or programming cycles. Because of this hybrid user structure, facility-mix decisions cannot be based only on architectural design quality, waterfront visibility, or market potential. They also require evidence about who is located near the pier, what kinds of facilities these groups may support, and how the pier can balance local everyday use with broader destination appeal.

Therefore, demographic analysis should not be understood as a deterministic tool that directly predicts facility success. Rather, it should be used as a planning instrument that helps interpret potential user demand and guide the proportional balance among facility categories. In the context of former industrial pier revitalization, this approach can help avoid two common problems: over-programming piers as tourist destinations disconnected from nearby communities, and under-programming them as passive public spaces without sufficient economic or social activity.

2.3. Hybrid Waterfront Planning: Stakeholder Integration and Community Needs

Waterfront redevelopment has historically been shaped by different planning styles, including plan-led public-sector approaches, market-driven development, and hybrid arrangements involving both public and private actors. Galland and Hansen (2012) argue that contemporary waterfront redevelopment increasingly moves between plan-led and market-driven styles toward hybrid forms of planning. This perspective is important because waterfront revitalization rarely depends on a single actor or planning logic. It typically involves public agencies, private developers, port authorities, local communities, cultural organizations, environmental groups, and tourism stakeholders.

Hybrid waterfront planning recognizes that successful redevelopment requires negotiation between public value, economic feasibility, design quality, and community needs. This is particularly important because former industrial waterfronts are often located near existing neighborhoods with specific social, economic, and cultural characteristics. If redevelopment is guided only by investment potential or destination branding, waterfront projects may become isolated consumption spaces rather than integrated urban places. Such outcomes can weaken public accessibility, increase social exclusion, and reduce the relevance of the waterfront for everyday users.

Classic urban public-space theory also supports this community-responsive view. Jacobs (1961), Whyte (1980), and Gehl (2011) emphasize that successful urban spaces depend on everyday use, human-scale activity, social interaction, and the relationship between spatial form and user behavior. Although these works are not pier-specific, they provide an important foundation for understanding why waterfront programming should respond to actual users rather than abstract design ideals alone.

However, community-responsive planning also requires practical analytical tools. Public participation can identify local concerns, values, and aspirations, but it does not automatically translate these concerns into facility-programming decisions. Similarly, social sustainability frameworks can define broad goals such as inclusiveness, accessibility, and public benefit, but they do not always explain how specific combinations of dining, retail, recreation, and entertainment should be selected for a particular waterfront site. This creates a gap between planning theory and programming practice.

Yocom et al. (2016) identify human well-being indicators for urban waterfront revitalization, showing the importance of evaluating waterfront projects in relation to social and community benefits. However, such indicators are more often used to assess waterfront outcomes than to guide the early-stage selection of facility mix. This study therefore positions demographic catchment analysis as a practical programming tool that complements broader community-engagement and social-sustainability frameworks.

A 15-minute catchment can be used to approximate the local population most likely to encounter or use a waterfront pier as part of everyday urban life. Within this catchment, age structure, median household income, and occupational profile can help planners interpret possible differences in daily routines, spending capacity, leisure preferences, and demand for different facility types. In this sense, demographic catchment analysis can function as a practical component of hybrid waterfront planning. It translates the abstract goal of community responsiveness into a more operational programming process.

2.4. Research Gap and Analytical Position

The reviewed literature establishes the importance of social responsiveness, facility diversity, and stakeholder integration in waterfront revitalization. However, three limitations remain.

First, waterfront revitalization studies often evaluate public-space quality, governance, sustainability, heritage reuse, urban design, or economic redevelopment outcomes, but provide limited guidance on how specific facility types should be programmed within former industrial pier structures. This is a significant limitation because piers have distinctive spatial conditions, including linear geometry, constrained footprints, limited entry points, and strong destination-oriented waterfront exposure.

Second, commercial and recreational facility-planning studies demonstrate the value of demographic analysis, but these methods have rarely been adapted to waterfront pier contexts. Facility planning literature often focuses on shopping centers, retail districts, mixed-use developments, or tourism destinations. Former industrial piers share some characteristics with these environments, but they also differ because they combine adaptive reuse, public waterfront access, leisure programming, and destination branding within a physically constrained structure.

Third, hybrid waterfront planning theory emphasizes the importance of community needs, stakeholder integration, and public benefit, but it does not always provide practical methods for translating community characteristics into early-stage facility-programming decisions. As a result, there remains a methodological gap between the theoretical demand for socially responsive waterfront redevelopment and the practical task of determining an appropriate facility mix.

This study addresses these limitations by positioning demographic catchment analysis as a bridge between community-oriented planning theory and facility-mix decision-making. By comparing the demographic profiles of 15-minute catchments with the proportional distribution of facility categories in four revitalized industrial piers, the study develops a set of exploratory planning implications for demographic-responsive pier programming. The purpose is not to claim that demographics alone determine facility success, but to demonstrate how demographic evidence can support more context-sensitive programming decisions in the adaptive reuse of former industrial waterfront infrastructure.

3. METHODOLOGY

3.1. Research Design

This study employs an exploratory comparative case study methodology to examine the relationship between facility mix and the demographic characteristics of surrounding urban contexts in revitalized former industrial waterfront piers. Rather than constructing a predictive or causal model, the study develops a comparative analytical framework for identifying how different types of commercial and recreational programming correspond to nearby user profiles.

The research process consists of four sequential stages. First, case study piers are selected according to typological, historical, spatial, and data-availability criteria. Second, a 15-minute catchment is defined for each pier in order to approximate the surrounding local user context. Third, demographic indicators within or immediately adjacent to each catchment are compiled and interpreted, focusing on age structure, median household income, and occupational profile. Fourth, the facility mix of each pier is classified into comparable program categories and measured as a proportion of total active programmable floor area. The demographic profiles and facility proportions are then compared across the four cases to identify recurring patterns of demographic–facility alignment.

This methodological approach is appropriate because the objective of the study is not to verify actual visitor origins or quantify post-occupancy behavior, but to evaluate how facility programming may be understood in relation to the socioeconomic characteristics of nearby potential users. Online visibility indicators are used to characterize each pier's visitor orientation — the reach of its user base beyond the resident catchment — and are not treated as measures of facility success.

3.2. Case Study Selection

The case studies were selected through four criteria designed to ensure comparability across different urban waterfront contexts. The four case selection criteria were developed from the analytical requirements of this study. Since the research aims to examine the relationship between facility mix and surrounding demographic characteristics, the selected cases needed to satisfy four methodological conditions: programmatic comparability, historical relevance, spatial comparability, and data reliability. Programmatic comparability is required because the study compares the proportional distribution of different facility types; therefore, each case must contain multiple active program categories rather than a single dominant use. Historical relevance is required because the study focuses on the revitalization of former industrial waterfront infrastructure; therefore, each case must have originated from a port-related, industrial, commercial, or transportation function. Spatial comparability is required because the study uses a 15-minute catchment as a proxy for the surrounding local user context; therefore, each case must remain at a scale where catchment-level demographic interpretation is still meaningful. Finally, data

reliability is required because the study depends on comparable demographic indicators across all cases; therefore, each case must be located in a context where publicly available demographic data can be obtained at an appropriate spatial resolution.

Criterion 1 — Multi-facility commercial programming (typological fit)

Each pier must operate as a multi-facility commercial and recreational destination. To be included, a pier must contain at least three of the four facility categories defined in Section 3.4 — table-service dining, counter-service dining, retail, and recreation or entertainment — co-located within a single pier structure, of which at least one must be non-dining. This criterion ensures that each case provides a sufficiently diverse facility mix for proportional comparison.

Criterion 2 — Post-industrial origin

Each pier must have originated as an industrial, commercial, or transportation-related port structure and subsequently been adapted for public leisure and commercial use. This criterion ensures that the selected cases are directly relevant to the study's focus on the revitalization of former industrial waterfront infrastructure, rather than purpose-built leisure piers or newly constructed commercial waterfront developments.

Criterion 3 — Neighborhood-scale catchment coherence

Each pier must remain within a scale at which a neighborhood-based catchment analysis is meaningful. This criterion ensures that the relationship between facility mix and surrounding demographic context can be reasonably interpreted. Very large waterfront complexes are excluded because their visitor base is more likely to be shaped by regional tourism, city-wide branding, transit accessibility, and event programming than by nearby demographic characteristics alone.

Criterion 4 — Demographic data accessibility and resolution

Comparable tract-level demographic data must be publicly available for each case. This criterion ensures that age structure, income level, and occupational composition can be analyzed consistently across the selected piers. Without comparable demographic data, the relationship between surrounding user context and facility mix could not be evaluated using the same analytical framework.

Based on these criteria, the study analyzes four cases: Pier 17 in New York, Pier 57 in New York, Pier 57 in Seattle, and Pier 39 in San Francisco. These cases provide variation in urban context, implementation period, facility composition, and visitor orientation while remaining comparable as former industrial waterfront piers adapted into multi-functional public destinations.

3.3. Catchment Definition and Demographic Profiling

For each case study, the surrounding local user context was approximated using a 15-minute catchment measured from the main public entrance of the pier. The 15-minute threshold follows the convention of neighborhood commercial and '15-minute city' planning, in which the area reachable within about 15 minutes on foot is treated as the zone of everyday, unplanned use of local facilities (Moreno et al. 2021); at a design walking speed of 80 m/min this corresponds to roughly 1,200 m, the radius used below. The catchment is a planning-scale proxy for the population most likely to encounter, access, or support the pier through everyday use; it does not represent a verified boundary of actual visitor origins.

Demographic profiles were compiled from the American Community Survey (ACS) 2019–2023 five-year estimates at census-tract level (U.S. Census Bureau 2024a), the smallest geography at which age, income, and occupation are all published. Because the ACS publishes no tabulation for named neighborhoods or walking isochrones, each catchment was operationalized as the set of census tracts whose population-weighted centroid lies within 1,200 m of the pier's main public entrance — the distance covered in 15 minutes at 80 m/min — excluding tracts with no land area and tracts separated from the pier by water (the Brooklyn and Jersey City tracts facing Pier 17 and Pier 57 New York). Tract centroids and land areas were obtained from the Census Bureau's TIGERweb service (U.S. Census Bureau 2024b). The rule yields 12 tracts for Pier 17, 13 for Pier 57 New York, 7 for Pier 57 Seattle, and 8 for Pier 39, listed with their populations and median incomes in Table 7 (Appendix); Figs. 2, 4, 6, and 8 show the approximate 15-minute walking areas for orientation only, and their boundaries do not coincide with the tract-based catchment. Because a Euclidean radius rather than a network isochrone is used, tracts at the margin of a catchment can fall just outside it; the most consequential case, the lower-income Chinatown tracts south of Pier 39 whose centroids lie 1.2–1.4 km from the entrance, is noted in Section 5.4.

Three variables were derived for each catchment by summing tract counts. Age structure uses ACS table S0101 (population by five-year age group), aggregated to ten-year cohorts and expressed as shares of total catchment population; the catchment median age is interpolated from the aggregated distribution. Income uses table B19001 (households by income bracket): the catchment median household income is estimated by linear interpolation within the bracket containing the median household and compared with the city median from the same ACS vintage (table B19013). Because a single median conceals within-catchment polarization, the range of tract medians and the shares of households earning under \$35,000 and \$150,000 or more are also reported. Occupational profile uses table S2401 (civilian employed population aged 16 and over by occupation), collapsed into five groups: professional (management, business and financial; education, legal, community service, arts and media; healthcare practitioners), STEM (computer, engineering and science), sales and office, service, and

manual and industrial (natural resources, construction and maintenance; production, transportation and material moving). These indicators are commonly used in retail, commercial, and mixed-use facility planning to estimate differences in spending capacity, daily-use patterns, leisure behavior, and preferred facility types, and every figure reported in Section 5 can be reproduced from the public ACS tables using the tract list in Table 7.

The demographic profile is therefore interpreted as an indicator of potential local user demand rather than as a direct description of actual visitors. This distinction is important because waterfront piers may also attract tourists, regional visitors, office workers, and event-based users whose origins extend beyond the 15-minute catchment.

3.4. Facility Classification and Floor-Area Measurement

Facility mix was analyzed by classifying active programmable spaces within each pier into four comparable categories: table-service dining, counter-service dining, retail, and recreation or entertainment.

Facility areas were estimated from the ground-floor plans published by the pier operators and their architects (both public levels at Pier 39). The plans were placed to scale in AutoCAD and the occupied footprint of each facility was traced as a closed polygon, with tenant boundaries checked against official tenant directories, Google Maps and Street View imagery, operator websites, and video walkthroughs. The plan scale was verified against documented dimensions of each pier: the 146 ft girder span of Pier 57 New York (Doswell 2003), the 400 ft by 140 ft pier shed of Pier 57 Seattle (Seattle Landmarks Preservation Board 2007), and the 60,000 sq ft floor plate of Pier 17 (Architect 2018); the traced dimensions agree with these references within 3–7%. Each category was then converted into a proportional value by dividing its estimated area by the total active programmable floor area of the pier. Table-service dining comprises establishments with seated, table-ordered service, including bar areas inside a restaurant and outdoor terraces attached to it, and bars and wine bars whose primary trade is drinks; counter-service dining comprises establishments where orders are placed at a counter, including individual food-hall and market stalls, each counted as a separate facility and measured by the stall footprint; shared seating operated by a food hall is assigned to counter-service dining, whereas the Living Room at Pier 57 New York, a free public gathering space managed by the park trust that is also used by Market 57 patrons, is classified as public space following the operator's designation. Traced footprints carry an estimated error of ± 10 –15% per facility, arising from line placement on raster plans (about 0.5 m), the scale assigned to the source plan, and tenant boundaries that may have changed since the plan was drawn; because every category of a pier is measured on the same plan, the category shares are insensitive to a uniform scale error, which affects only the absolute areas. The estimated programmable area, the area of each category, and the facilities with their estimated areas and classification are given for each pier in Table 8 (Appendix), and Table 1 reports the programmable-area denominator alongside total floor area so that the two are not confused.

Circulation spaces, including corridors, waterfront promenades, stairs, elevators, toilets, service zones, and general outdoor movement areas, were excluded from the facility proportion calculation. This exclusion allows the study to compare active program allocation rather than total pier area, which can vary substantially according to pier geometry, access configuration, promenade width, and public circulation design.

Three further conventions govern this measurement and are stated here because they affect the recreation share in particular. First, open-air facilities are included when they are operated as a named, ticketed, or managed attraction with a defined footprint — the Great Wheel and the boat-tour berth at Pier 57 Seattle, and the sea lion docks and carousel at Pier 39 — and are measured by their operated footprint, including queuing and viewing areas. Undifferentiated open space, such as the waterfront promenade, the general public deck, and the rooftop park at Pier 57 New York, is treated as parkland or circulation and excluded, so that the rooftop park, although the pier's anchor recreational attraction, enters the analysis qualitatively rather than as floor area. Second, non-public uses are excluded from the denominator: the office floors that occupy most of the upper levels of Pier 57 New York, the broadcast studio and upper-level event floors at Pier 17, the marina berths at Pier 39, and back-of-house, storage, and management space in all four piers. Third, the inventory is a snapshot of the 2024 survey date: a unit at the river end of Pier 57 New York that was unoccupied at the time (opened in 2025 as a bar) is excluded, and tenants named in Table 8 are those identified for that date. The reported proportions therefore describe the allocation of publicly accessible programmed area rather than of the pier building as a whole. Because the recreation category contains open-air attractions whose operated footprint is small relative to their visitor draw (most clearly the Great Wheel), recreation shares understate the significance of these facilities and should be read alongside the facility counts given in Section 5.

3.5. Comparative Interpretation and Methodological Limitations

The final stage of analysis compares the demographic profile of each catchment with the proportional distribution of facility categories within each pier. The comparison focuses on whether particular demographic contexts appear to correspond with distinctive facility-mix patterns. For example, higher-income professional contexts may support a greater proportion of table-service dining and experiential leisure, while income-diverse or tourism-oriented contexts may support a broader mix of counter-service dining, retail, and entertainment facilities.

The study uses triangulation to strengthen interpretation. Demographic data provide evidence of potential local user demand, facility proportions provide evidence of programmatic allocation, and normalized online visibility indicators characterize visitor orientation, that is, the extent to which each pier draws users from beyond its resident catchment. These data are interpreted cautiously because they do not measure the same phenomenon: demographic data describe nearby residents, facility proportions describe spatial programming, and online indicators reflect destination reach but also platform behavior, landmark status, and time since opening.

Several limitations should therefore be acknowledged. First, the catchment — census tracts within a 1.2 km radius of the entrance — is a proxy for local context rather than a verified visitor-origin boundary, and a Euclidean radius does not reproduce a street-network isochrone exactly. Second, demographic indicators cannot fully capture visitor motivations, tourist behavior, seasonal variation, or event-based use. Third, facility floor-area estimates rely on publicly available information and may contain minor measurement inaccuracies where tenant plans are incomplete. Fourth, the selected cases are located in the United States, which allows demographic data consistency but limits direct generalization to other national planning systems.

Fifth, and most significantly, each case pier possesses a distinctive landmark or anchor asset — Pier 39's sea lion colony, Pier 17's rooftop concert venue, Pier 57 Seattle's Great Wheel — that plausibly shapes both facility programming and visitor engagement independently of catchment demographics. Because asset type and demographic profile co-vary across only four cases, this study cannot isolate the demographic contribution to facility mix from the contribution of these site-specific assets. The correspondences reported in Section 5 should therefore be read as consistent with a demographic–facility relationship, not as evidence that rules out landmark-asset-driven explanations for the same patterns.

Despite these limitations, the methodology provides a replicable procedure for early-stage pier revitalization planning. By linking facility mix to surrounding demographic conditions, the study offers a practical way to incorporate user-context evidence into the programming of former industrial waterfront piers.

4. CASE STUDY BACKGROUND AND VISITOR ORIENTATION

4.1. Overview of Selected Piers

Table 1 provides an overview of the four case study piers, including location, previous use, implementation year, pier area, and total facility floor area.

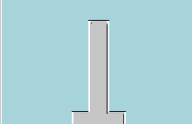
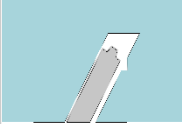
Attribute	Pier 17 (New York)	Pier 57 (New York)	Pier 57 (Seattle)	Pier 39 (San Francisco)
Photo				
Pier Site Plan				
Location	89 South Street, Lower Manhattan	25 11th Avenue, Hudson River Park	1301 Alaskan Way	The Embarcadero
Pier Area	19,224 m ²	16,535 m ²	6,990 m ²	27,911 m ²
Total Floor Area	7,271 m ²	13,417 m ²	4,041 m ²	37,838 m ²
Programmable Floor Area (denominator)	3,046 m ²	3,659 m ²	2,562 m ²	21,867 m ²
Floors Used	2	2	1	2
Implementation Year	2018	2023	2012	1978
Previous Use	Fulton Fish Market pier	Cargo terminal / Bus depot	Cargo shipping	Industrial pier

Table 1 Overview of selected case-study piers

4.2. Visitor Orientation: Normalized Online Visibility Indicators

Table 2 characterizes each pier's visitor orientation with publicly available online visibility indicators: Instagram post counts, Google Maps ratings and review volumes, and Google Trends search interest from 2004 to 2024. Because the raw

counts are cumulative and the piers reopened in different years (Pier 39 in 1978, Pier 57 New York in 2023), two normalized measures are added: Google Maps reviews per 1,000 catchment residents, which expresses each pier's reach relative to its resident base, and reviews per year since reopening, which corrects for exposure time. The indicators remain affected by platform use, landmark status, and tourism volume, and are used only to place the four piers on a scale from locally oriented to tourist-dominated; they are not used as measures of facility success.

Metric	Pier 17 (NY)	Pier 57 (NY)	Pier 57 (Seattle)	Pier 39 (SF)
Instagram Posts	33,800	16,800	7,000	43,000
Google Maps Rating	4.6 / 5.0	4.7 / 5.0	4.5 / 5.0	4.6 / 5.0
Google Maps Reviews	10,954	982	1,525	126,688
Reviews per 1,000 catchment residents	174	14	59	6,874
Reviews per year since reopening	1,826	982	127	2,754
Top Mentioned Feature	Concert venue; Restaurants	Food court; Rooftop	Great Wheel; Food	Sea lions; Restaurants; Shops
Google Trends Peak	Post-2018 spike	Post-2023 spike	Minimal post-2012 gain	Consistently high since 2004

Table 2 Online visibility indicators used to characterize visitor orientation (cumulative counts to 2024, with normalized values)

The normalized indicators separate the four piers clearly. Pier 39, with about 6,900 Google Maps reviews per 1,000 catchment residents and some 2,750 reviews per year since reopening, is tourist-dominated by any measure, consistent with its ranking as the most-visited attraction in San Francisco (Section 5.4). Pier 17 (about 170 reviews per 1,000 residents; about 1,800 per year) is a mixed destination that draws well beyond its catchment, as its post-2018 search spike also indicates. Pier 57 Seattle (about 60 per 1,000 residents; about 130 per year) and Pier 57 New York (about 14 per 1,000 residents; about 980 in its first year) are the two most locally oriented, the latter's low cumulative figures reflecting both its recent opening and its position within Hudson River Park. These positions — tourist-dominated (Pier 39), mixed (Pier 17), and locally oriented (the two Pier 57s) — are carried into Section 5 as the visitor-orientation dimension of each case.

5. DEMOGRAPHIC CONTEXT AND FACILITY PROPORTION

This section compares the demographic profile of each pier's 15-minute catchment with the proportional distribution of facility types within the pier. Each case is discussed through three elements: the surrounding demographic context, the facility distribution, and the possible correspondence between demographic characteristics and programming strategy. The analysis does not treat demographic profile as a direct predictor of facility success, but as a planning indicator for interpreting how facility mix may relate to nearby user context. All demographic indicators in this section are catchment aggregates of ACS 2019–2023 five-year tract estimates compiled as described in Section 3.3 (U.S. Census Bureau 2024a); Tables 3–5 summarize them, and Table 7 (Appendix) lists the constituent tracts.

Pier	Tracts (n)	Population	Median age	<20 (%)	20s (%)	30s (%)	40s (%)	50s (%)	60s (%)	70+ (%)	65+ (%)
Pier 17 (NY)	12	62,986	35	16.1	22.0	20.4	13.5	11.0	8.2	8.9	13.3
Pier 57 (NY)	13	69,046	43	10.6	17.1	18.9	13.6	15.0	12.0	12.8	18.0
Pier 57 (Seattle)	7	25,641	35	3.7	29.0	26.9	9.1	11.6	9.9	9.8	14.0
Pier 39 (SF)	8	18,429	42	11.4	15.8	20.2	13.3	13.0	13.5	12.7	19.8

Table 3 Age structure of the 15-minute catchments (ACS 2019–2023 five-year estimates; shares of total catchment population)

Pier	Households	Catchment median HH income (US\$, est.)	Range of tract medians (US\$)	City median (US\$)	Catchment / city	Households < \$35,000 (%)	Households ≥ \$150,000 (%)
Pier 17 (NY)	29,359	134,900	11,612 – 250,000+	79,713	1.69	21.3	46.1
Pier 57 (NY)	39,807	140,500	70,816 – 250,000+	79,713	1.76	15.4	47.7
Pier 57 (Seattle)	16,304	111,000	39,117 – 170,700	121,984	0.91	23.0	39.8
Pier 39 (SF)	10,009	133,900	80,472 – 207,500	141,446	0.95	22.7	46.8

Table 4 Household income of the 15-minute catchments (ACS 2019–2023 five-year estimates; catchment medians interpolated from table B19001; tract medians from table B19013, top-coded at \$250,000)

Pier	Civilian employed (16+)	Professional (%)	STEM (%)	Sales and office (%)	Service (%)	Manual and industrial (%)
Pier 17 (NY)	37,191	54.4	10.8	18.6	11.9	4.3
Pier 57 (NY)	42,836	63.2	9.5	17.1	6.7	3.5
Pier 57 (Seattle)	17,337	40.2	33.0	10.3	11.3	5.3
Pier 39 (SF)	11,363	53.0	15.4	17.2	8.3	6.1

Table 5 Occupational profile of the 15-minute catchments (ACS 2019–2023 five-year estimates, table S2401; shares of civilian employed residents aged 16 and over)

5.1. Pier 17, New York: Young, Affluent, and Polarized

Pier 17 is situated at 89 South Street in Lower Manhattan, adjacent to the Financial District, Civic Center, and Two Bridges neighborhoods within the 15-minute catchment shown in Fig. 2. This catchment provides the spatial basis for interpreting Pier 17's demographic context and comparing its facility mix with the surrounding population profile summarized in Tables 3–5.

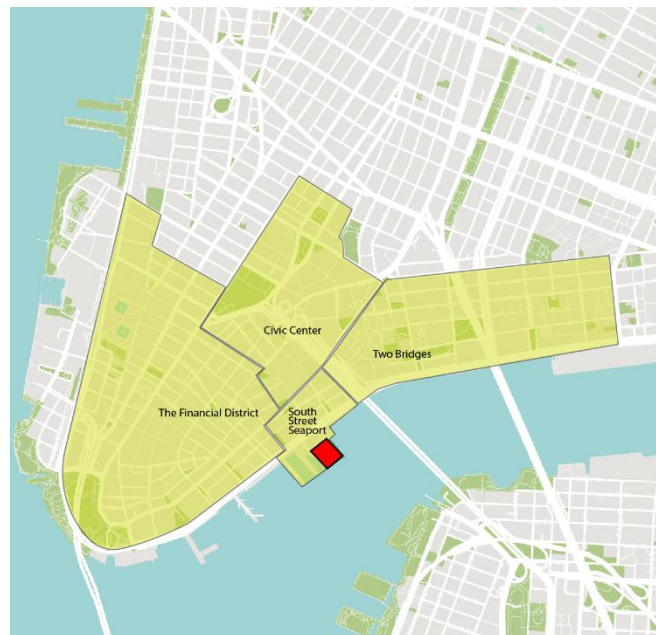


Fig. 2 Approximate 15-minute walking area around Pier 17, New York, shown for orientation only; the tract-based catchment used in the analysis (Section 3.3, Table 7) does not coincide with this boundary

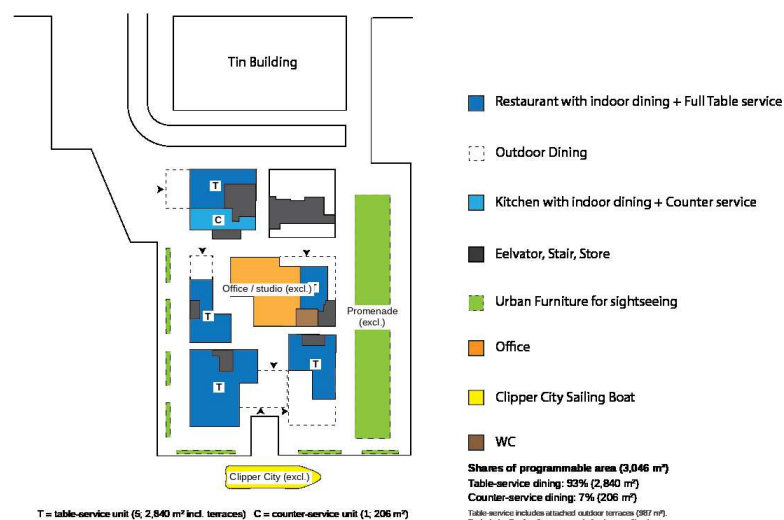


Fig. 3 Facility distribution of Pier 17, New York, ground level (plan: SHoP Architects 2024), with category shares of programmable floor

area and estimated areas; T = table-service unit, C = counter-service unit (tenants in Table 8)

The Pier 17 catchment (12 tracts, about 63,000 residents) spans the Financial District, the Civic Center, the South Street Seaport, and the western part of Two Bridges and Chinatown. In its working-age profile it is one of the two youngest of the four: 42% of residents are in their 20s and 30s and the median age is about 35 (Table 3). It is also affluent: the estimated catchment median household income of about \$134,900 is 1.69 times the New York City median, 46% of households earn \$150,000 or more, and 54% of employed residents work in professional occupations with a further 11% in STEM fields, while manual and industrial occupations account for only 4% (Tables 4 and 5). The catchment is, however, sharply polarized. Three tracts on its eastern edge (tracts 8, 25, and 29.01), housing 23% of catchment residents, have median household incomes of \$34,000, \$23,700, and \$11,600 respectively — below 45% of the city median — and 21% of all catchment households earn under \$35,000, while the Financial District tracts to the west record medians between \$180,000 and \$250,000 or more. Pier 17's programming does not respond to the lower-income segment; it is oriented to the affluent resident and daytime office population and to visitors. This indicates a boundary condition of the catchment approach: where a catchment is sharply polarized, facility mix tends to follow the dominant spending segment rather than the catchment average, and the resulting under-provision for lower-income residents should be read as a planning finding in its own right rather than as confirmation of alignment.

Pier 17's facility mix corresponds to the dominant, affluent segment of its catchment rather than to the catchment as a whole. As indicated in Fig. 3, approximately 93% of the pier's active programmable floor area (2,840 of 3,046 m², including about 990 m² of attached outdoor terraces) is allocated to five table-service restaurant units offering outdoor dining, indoor dining, and dedicated bar areas — at the survey date The Fulton, Carne Mare, Malibu Farm, and two units formerly occupied by Momofuku's Ssäm Bar and Bar Wayō (Table 8). Only one counter-service outlet (Mister Dips, 206 m²) is provided, suggesting that quick and budget-oriented dining plays a relatively limited role in the pier's current programming strategy. No retail or recreational facilities are provided at ground level; the pier functions primarily as a dining and event-oriented destination, supplemented by a rooftop concert venue and upper-level event floors, which lie outside the measured area and further support its premium leisure positioning.

The compact spatial configuration of Pier 17 reinforces its interpretation as a destination-oriented dining and event pier. Rather than requiring users to navigate a complex multi-functional environment, the pier's organization supports relatively direct access to dining venues and rooftop event space. The rooftop deck, positioned at the highest depth level, serves as a destination reward requiring intentional navigation, consistent with its higher-end dining and event positioning.

5.2. Pier 57, New York: Affluent, Older, and Professional

Pier 57 New York is located at 25 11th Avenue in Hudson River Park, and its catchment (13 tracts, about 69,000 residents; Fig. 4) covers Chelsea, the Meatpacking District, and the northern West Village. The catchment is the most affluent and the most professional of the four: the estimated median household income of about \$140,500 is 1.76 times the city median, 48% of households earn \$150,000 or more, and 63% of employed residents work in professional occupations, with 17% in sales and office, 7% in service, and under 4% in manual and industrial occupations. Only 15% of households earn under \$35,000, the lowest share of the four, and the two lowest tract medians (\$70,800 in tract 97 and \$79,000 in tract 83, both containing long-established cooperative and public housing) remain close to the city median. What distinguishes this catchment from Pier 17's is age rather than income: the median age is about 43, 18% of residents are aged 65 or over, and 27% are in their 50s and 60s, compared with 13% and 19% at Pier 17.



Fig. 4 Approximate 15-minute walking area around Pier 57, New York, shown for orientation only; the tract-based catchment used in the analysis (Section 3.3, Table 7) does not coincide with this boundary

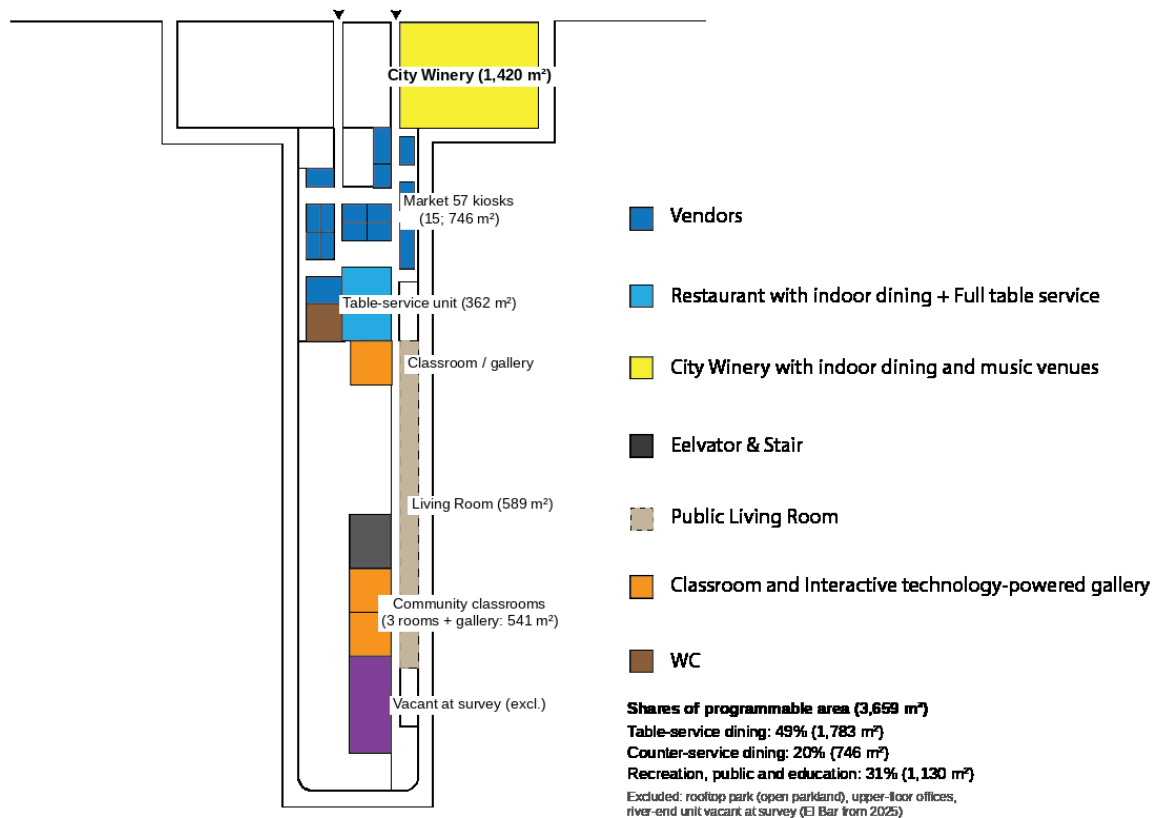


Fig. 5 Facility distribution of Pier 57, New York, ground level (plan: Pier 57 NYC 2024; Hudson River Park 2024), with category shares of programmable floor area and estimated areas

Read against this profile, the facility mix at Pier 57 New York cannot be explained by resident income, which would predict a Pier 17-type program. In Fig. 5, the pier provides 15 vendor-format counter-service kiosks in the Market 57 food hall (approximately 20% of active programmable floor area; 746 of 3,659 m²), two table-service venues (approximately 49%,

of which City Winery's restaurant and music venue alone accounts for 39%), and a combined public and educational component of approximately 31%, comprising the Living Room, a free indoor public space, and three community classrooms with an interactive gallery (the Discovery Tank); there is no retail component. The rooftop park, the pier's anchor recreational attraction, lies outside the programmable area by the convention of Section 3.4 and would raise the public-space share further if counted. Two features of the context not captured by resident statistics are more plausible explanations. The first is the daytime population: the pier's own upper floors and the surrounding blocks house major technology-company offices, and the vendor-format dining is better understood as serving these workers and park visitors than resident administrative workers. The second is the pier's position within Hudson River Park and beside an older resident base, for whom public space, a rooftop park, and educational program carry more weight than retail. The mix therefore reads as a response to the catchment's age structure and to its non-resident daytime users rather than to its income level.

Pier 57 New York is the most locally oriented of the four piers on the normalized indicators in Table 2 (about 14 reviews per 1,000 catchment residents), although its first-year review rate is comparable to Pier 17's annual rate. A locally oriented user base is consistent with the public-space and educational emphasis of its program, and its position within Hudson River Park, beside a corridor where casual dining and entertainment are already abundant, makes a destination-retail program less necessary than at Pier 39. This reading is tentative, since online visibility is also shaped by opening year, branding, and platform behavior.

5.3. Pier 57, Seattle: Young, Technology-Employed, Near the City Median

Pier 57 Seattle is located at 1301 Alaskan Way, and its catchment (7 tracts, about 25,600 residents; Fig. 6) covers the central waterfront, Pike Place Market, Belltown, and the western downtown core. It is the youngest and the most occupationally distinctive of the four: 56% of residents are in their 20s and 30s and only 4% are under 20 (median age about 35), and 33% of employed residents work in STEM occupations — roughly three times the share at Pier 17 and twice that at Pier 39 — with a further 40% in other professional occupations, reflecting the concentration of technology employment in and around downtown Seattle. Its income position is close to the city median: the estimated catchment median household income of about \$111,000 is 0.91 of the Seattle median, and 40% of households earn \$150,000 or more. At the same time it has the largest low-income share of the four — 23% of households earn under \$35,000 — concentrated in the Pioneer Square tract (tract 92, median \$39,100) and in downtown single-room and subsidized housing. The catchment is therefore best described as young, technology-employed, and near the city median, with a sizeable low-income minority, rather than as uniformly moderate in income.

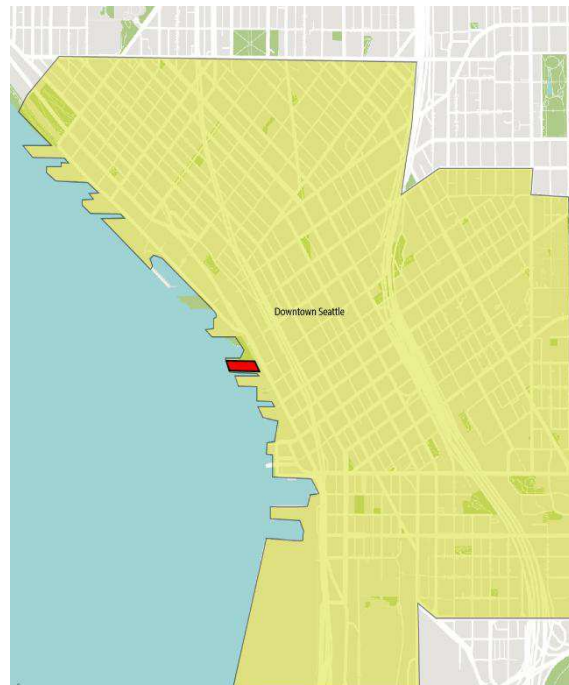


Fig. 6 Approximate 15-minute walking area around Pier 57, Seattle, shown for orientation only; the tract-based catchment used in the analysis (Section 3.3, Table 7) does not coincide with this boundary

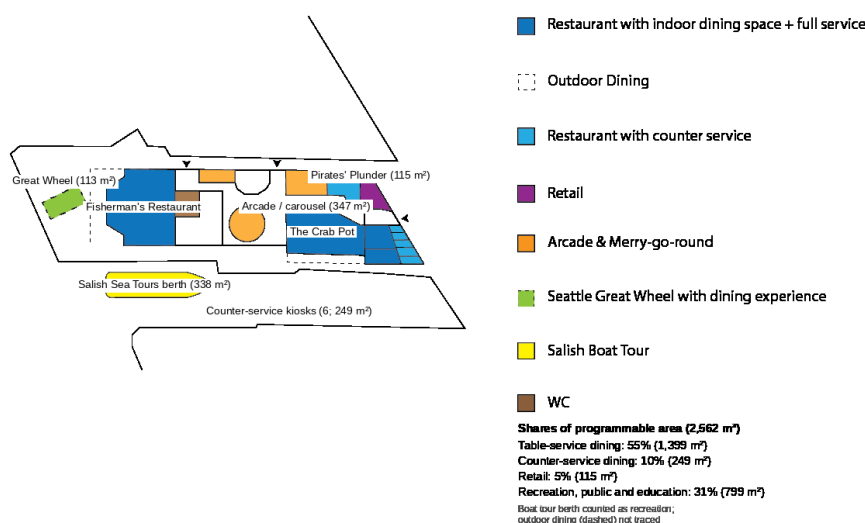


Fig. 7 Facility distribution of Pier 57, Seattle (plan: Miners Landing 2024), with category shares of programmable floor area and estimated areas

As shown in Fig. 7, Pier 57 Seattle's facility programming is only partially explained by this resident profile: four table-service restaurant units (approximately 55% of active programmable floor area; 1,399 of 2,562 m²), led by The Crab Pot and The Fisherman's Restaurant in a traditional, nautically themed interior; six counter-service units prominently positioned along the entrance promenade (approximately 10%); and a single retail shop (approximately 5%). Recreation and entertainment account for approximately 31%, distributed across the Seattle Great Wheel, an arcade and carousel, and the Salish Sea Tours boat berth. The Great Wheel generates the highest visitor mentions in Google Maps reviews while occupying only a small share of the pier's floor area (113 m²). A young, single-person, technology-employed catchment would be expected to support counter-service and casual formats more strongly than it does; the predominance of table-service dining is more plausibly a response to the pier's cruise-terminal and tourist orientation on the central waterfront than to its residents. On the normalized indicators in Table 2, Pier 57 Seattle is locally to moderately oriented (about 60 reviews per 1,000 catchment residents, far below Pier 39 and Pier 17), which suggests that its tourist and cruise-terminal draw, while real, is modest in scale; its dining-led program therefore serves a mixed rather than a tourist-dominated user base.

5.4. Pier 39, San Francisco: Multi-Generational and Tourism-Integrated

Pier 39, located at The Embarcadero, has the smallest resident catchment of the four (8 tracts, about 18,400 residents; Fig. 8), covering Fisherman's Wharf, North Beach, Telegraph Hill, and the eastern edge of Russian Hill. It is the most multi-generational: 20% of residents are aged 65 or over, 26% are in their 60s or older, and the age distribution is spread evenly across cohorts (median age about 42). Income is close to the city median (estimated catchment median about \$133,900, 0.95 of the San Francisco median), with tract medians ranging from \$80,500 on the Chinatown edge (tract 107.02) to \$207,500 on Telegraph Hill; 23% of households earn under \$35,000 and 47% earn \$150,000 or more. The lower-income Chinatown tracts immediately to the south (for example tract 107.01, median \$27,500) lie just beyond the 1.2 km centroid threshold and would raise the low-income share further if included, so the catchment is more income-diverse than its summary figures alone suggest. Occupationally it is professional (53%) with a moderate STEM share (15%).

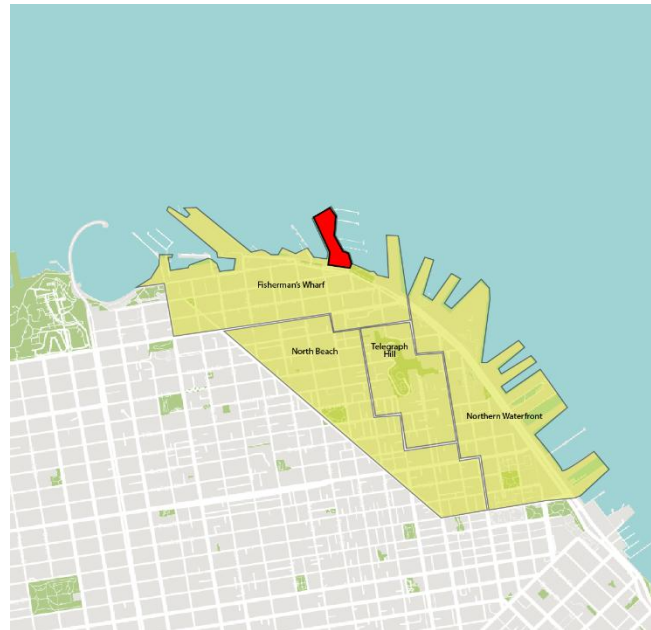


Fig. 8 Approximate 15-minute walking area around Pier 39, San Francisco, shown for orientation only; the tract-based catchment used in the analysis (Section 3.3, Table 7) does not coincide with this boundary

In addition to local residents, Pier 39 serves a large international tourist population: the San Francisco Travel Association's Visitor Profile Study (2019) consistently ranks Pier 39 as the most-visited attraction in San Francisco, with the sea lion colony at K Dock serving as a uniquely non-replicable natural attraction that draws visitors regardless of facility programming. This dual user base may help explain the pier's more balanced facility mix.

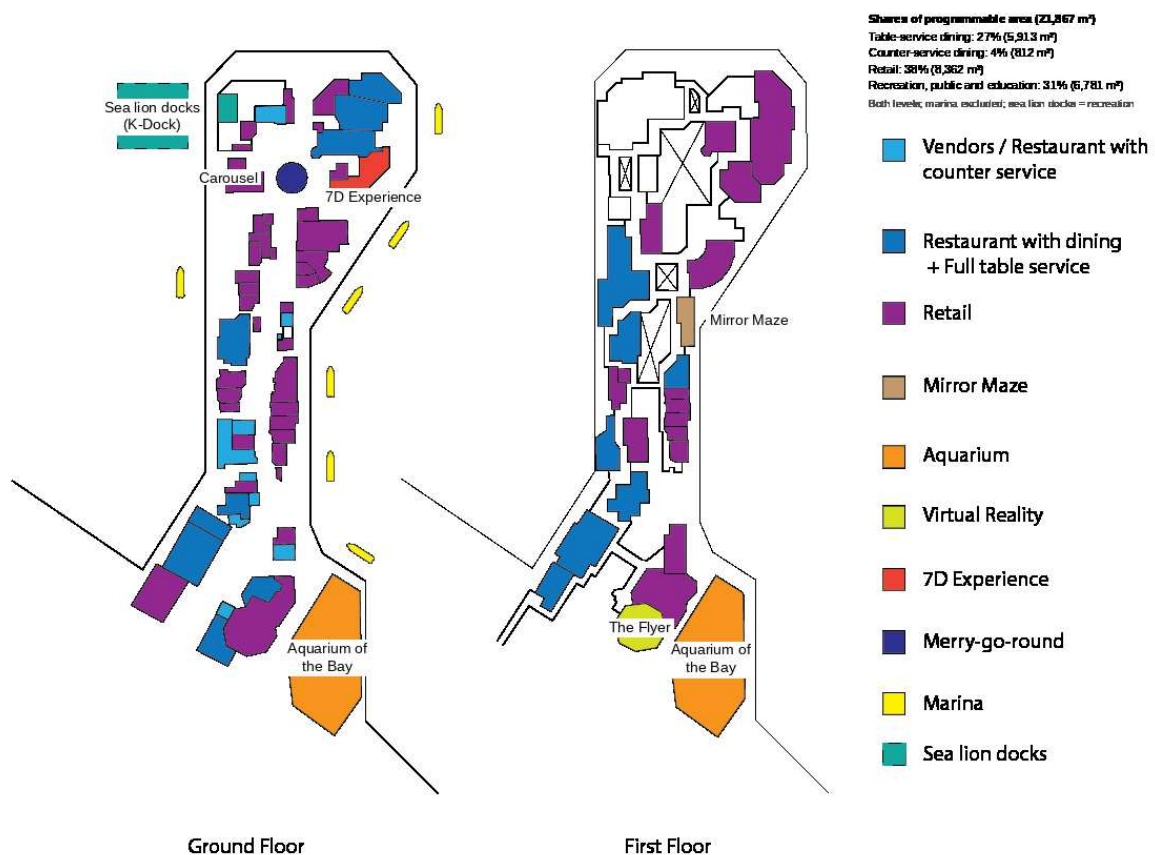


Fig. 9 Facility distribution of Pier 39, San Francisco, ground and first levels (plan: Pier 39 2024), with category shares of programmable floor area and estimated areas

Within Pier 39's programmable floor area (21,867 m² over two levels; Table 1), the facility distribution in Fig. 9 includes 16 table-service restaurants (approximately 27% of active programmable floor area), nine counter-service outlets (approximately 4%), 52 retail shops (approximately 38%), and a diverse array of recreational attractions including the Aquarium of the Bay, the sea lion docks, the carousel, the mirror maze, the 7D ride, and the Flyer (collectively approximately 31%). This balanced, multifunctional distribution may be interpreted as a programming strategy capable of serving multiple user groups simultaneously, including high-spending tourists, local residents, and family-oriented visitors.

5.5. Comparative Facility Proportion Analysis

Fig. 10 presents the comparative facility proportion data across the four case studies, organized by facility type.

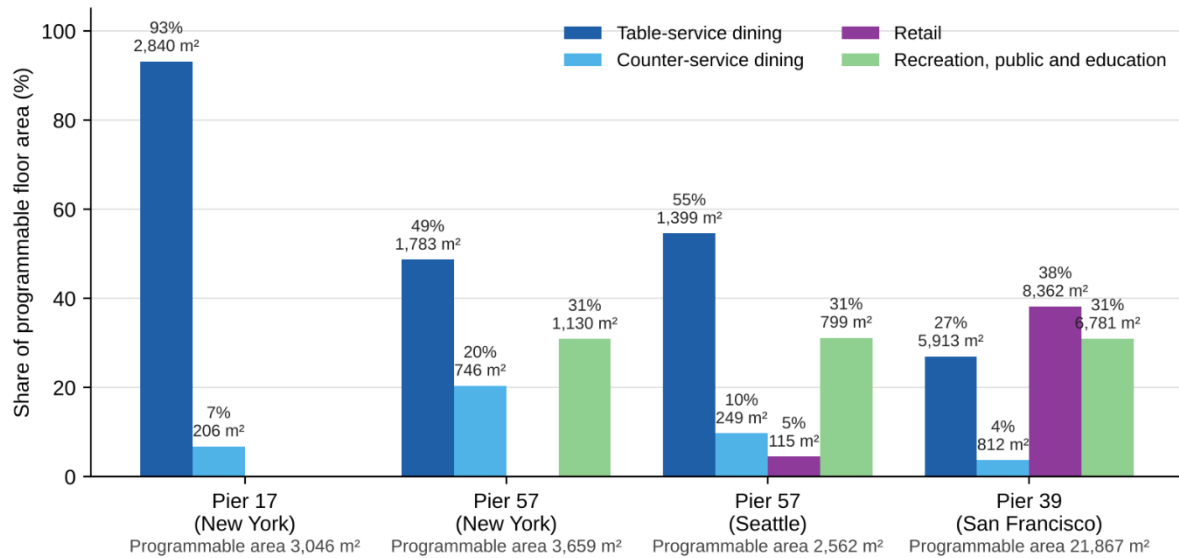


Fig. 10 Comparative facility proportion across case studies: shares of programmable floor area with estimated areas in m² (inventory in Table 8)

Across the four selected cases, the facility diagrams suggest differentiated programming strategies when read alongside the demographic profiles in Fig. 10. Pier 17 emphasizes table-service dining and event-oriented programming, Pier 57 New York combines vendor-format dining with public and educational amenities, Pier 57 Seattle combines a dining-led mix with a distributed recreational offer, and Pier 39 displays the most diversified distribution across dining, retail, and recreation or entertainment.

Read against the catchment profiles in Tables 3–5, the facility proportions show a weak correspondence with income level and a clearer one with age structure and with visitor orientation. All four catchments are affluent by national standards: the two New York catchments stand at roughly 1.7 times their city median and the Seattle and San Francisco catchments at 0.9–0.95 of theirs. Income alone therefore does not discriminate between Pier 17's almost exclusively table-service program and Pier 57 New York's balanced one, since the two catchments are equally affluent. What differs between them is age structure and daytime population: the Pier 57 catchment is a decade older, with 18% of residents over 65, and sits beside large office concentrations and a linear park, and its program leans correspondingly toward public, educational, and quick-service space. Across the four cases, the two catchments with the largest shares of residents aged 60 and over (Pier 57 New York, 25%; Pier 39, 26%) are the two piers that devote the largest shares of programmable area to free public, educational, and family-oriented space (31% at Pier 57 New York, all of it the Living Room and the classrooms, with the rooftop park uncounted; 31% at Pier 39, led by the aquarium and the free sea lion docks), while the two youngest catchments (Pier 17 and Pier 57 Seattle, with 42% and 56% of residents in their 20s and 30s) are the two piers most dominated by table-service dining (93% and 55%), and the only ones with no public or educational space; Pier 57 Seattle's recreation share (31%) consists of ticketed attractions — the Great Wheel, the arcade, and the boat tour — rather than public space. Visitor orientation adds a further axis: the only pier with a substantial retail share (Pier 39, 38%) is the one whose user base is tourist-dominated on the normalized indicators in Table 2, while the two most locally oriented piers (the two Pier 57s) have no retail or almost none. Occupational profile, the third demographic variable, discriminated little: professional occupations account for 40–63% of employed residents in all four catchments and manual and industrial occupations for under 7%, so the only occupational feature that distinguishes a

case is Pier 57 Seattle's STEM share (33%, against 10–15% elsewhere), and that feature reinforces the age-based reading of the catchment as a young technology workforce rather than adding an independent dimension. These are exploratory patterns across four cases, not statistically generalizable relationships.

At the same time, the cases show that demographic context alone does not explain facility mix. Tourism intensity, pier size, redevelopment history, landmark attractions, surrounding competition, and governance structure also shape programming outcomes. Pier 39's sea lion colony and tourism identity, Pier 17's rooftop event venue, Pier 57 New York's integration with Hudson River Park, and Pier 57 Seattle's Great Wheel all demonstrate that facility mix is shaped by both local demographic context and destination-specific assets — and critically, this study's design cannot separate the two. Disentangling these effects would require pairs of piers that hold either the landmark asset or the catchment profile constant; no such pair exists among the four cases, and the two most affluent catchments (both New York piers) differ in both their landmark assets and their programs. The demographic–facility correspondence reported here is therefore better understood as one plausible contributor among several co-occurring factors, not as an isolated or dominant one.

6. DISCUSSION

This study advances the understanding of demographic–facility alignment in waterfront pier revitalization in three ways. First, it provides exploratory empirical evidence that the age structure of the 15-minute catchment and the pier's visitor orientation are associated with facility mix across the selected cases, whereas income level and occupational profile are not — though these associations remain difficult to separate from the influence of each pier's distinctive landmark asset. Pier 39's sea lion colony and Pier 17's rooftop venue may generate the broad visitor reach recorded in Table 2 largely independently of catchment demographics, and the retail-heavy and dining-heavy programs of those two piers may follow from the assets rather than from the populations around them. This study's design does not adjudicate between these explanations, and future work with a larger, asset-controlled case sample would be needed to do so.

Second, the study contributes a comparative interpretation of demographic–facility relationships in revitalized industrial waterfront piers, and a methodological correction. Income level, often treated as the primary discriminator in trade-area analysis, proved far less informative than expected once the catchments were profiled from tract-level census data: all four are affluent, and the two most affluent (both New York piers) have the most and the least dining-led programs. Age structure, non-resident daytime population, and tourist orientation discriminate more clearly. Older, multi-generational catchments coincide with larger public, recreational, and educational shares; young, working-age catchments with dining-led programs; and a tourist-dominated visitor base with a substantial retail share. Rather than proposing a fixed typological model, the findings therefore suggest that early-stage programming should weigh the age structure of the surrounding population and the size of the non-resident user base at least as heavily as its income, and that the internal polarization of a catchment, not only its average, determines whom the resulting program serves.

Table 6 summarizes these observed correspondences as planning implications: for each catchment condition it lists the programming emphasis observed, the facility types that the cases suggest should be prioritized, and the relevance of the condition to Busan North Port (Section 7).

Catchment condition	Programming emphasis observed	Case	Facility types to prioritize	Relevance to Busan North Port
Young, affluent, professional residents (median age ~35; 1.7× city median income) with a large daytime office population; low-income tracts on the catchment edge	Table-service dining and event programming dominate (93% of programmable area); no retail or recreation at ground level	Pier 17 (NY)	Table-service dining; event and venue space	Not the North Port condition; cautions against a premium dining-led model
Equally affluent but older catchment (median age ~43; 18% aged 65+), highly professional; beside office concentrations and a linear park	Vendor-format counter-service dining on the main route (20%), two table-service venues led by City Winery (49%), public and educational amenities (31%) plus a rooftop park; no retail	Pier 57 (NY)	Counter-service (vendor) dining; public, educational, and park-type space; one anchor venue	Relevant to the aging adjoining districts and to the daytime worker demand implied by planned office uses
Young, technology-employed residents near the city median income (0.9×), with a low-income pocket (23% of households under \$35,000)	Dining-led mix (55% table-service) with entrance-positioned counter service (10%), small retail (5%), distributed recreation (31%)	Pier 57 (Seattle)	Casual and counter-service dining at the entrance; distributed small-scale recreation	Partial analogue through its cruise-terminal orientation; recreation share supports multi-generational use
Multi-generational residents near the city	Balanced four-category mix: retail 38%, recreation 31%, table-	Pier 39 (SF)	Balanced: retail, recreation, and both dining	Closest analogue: aging, modest-income adjoining

median income (0.95×; 20% aged 65+) combined with a very large tourist inflow	service 27%, counter-service 4%		formats	districts plus cruise and rail visitor flow
Polarized catchment: dominant affluent segment adjoining low-income tracts (23% of residents in tracts below 45% of the city median)	Mix follows the dominant spending segment; lower-income residents not served	Pier 17 / Two Bridges	Affordable counter-service dining; everyday retail; free public and age-friendly space	Foreseeable risk where new development adjoins Dong-gu and Jung-gu; resident-oriented program should be an explicit allocation

Table 6 Observed demographic–facility correspondences, facility types to prioritize under each catchment condition, and relevance to Busan North Port (percentages are approximate shares of programmable floor area)

Third, the approach's explicit connection to hybrid planning theory addresses a gap identified by Evans et al. (2025): the lack of systematic tools for incorporating community socioeconomic characteristics into waterfront programming decisions prior to final design. By showing that structured demographic analysis of the 15-minute catchment can help identify different programming conditions across the selected cases, the study provides a practical, low-cost instrument that can be integrated into early-stage stakeholder engagement and programming discussions. This is particularly significant for the second-wave Asian port cities, including Busan, Kobe, and Singapore, where hybrid governance structures are being established but demographic-responsive programming methodologies are not yet developed.

Several limitations warrant acknowledgment. The facility proportion data are based on publicly available architectural plans and on-site documentation, and may not perfectly reflect operational programming at any given time, as piers regularly cycle tenants; traced footprints carry an estimation error that Table 8 makes explicit. The 15-minute catchment boundary assumes consistent pedestrian accessibility, whereas actual visitor origins may extend further, particularly for tourist-oriented piers served by transit or ferry. The study does not propose a fixed typology because the four selected cases represent a limited sample and are located in North American contexts. The findings should therefore be understood as exploratory planning implications that require further testing in Asian port-city contexts. Future research should also integrate post-occupancy behavioral mapping and mobile phone origin-destination data to test whether the demographic–facility relationships identified in this study correspond with observed movement patterns and visitor behavior.

7. CONCLUSION

This paper has examined the relationship between demographic context and facility programming in four revitalized industrial waterfront piers, using catchment profiles built from tract-level census data. The comparative analysis suggests that facility mix corresponds less with the income level of the surrounding population — all four catchments are affluent, and the two most affluent have the most and the least dining-led programs — than with its age structure, the size of the non-resident daytime and tourist user base, and the internal polarization of the catchment, while also showing that these correspondences cannot be separated from the influence of each pier's landmark asset within a four-case design.

Rather than establishing a fixed typological framework, this study identifies comparative planning implications for demographic-responsive pier revitalization. The findings suggest that facility programming should be evaluated in relation to the socioeconomic and demographic profile of the surrounding local user context, while also accounting for tourism demand, transit access, waterfront visibility, and destination identity. The approach is grounded in the community-engagement logic of hybrid waterfront planning; specifically, it provides the methodological mechanism for making the "community needs" dimension of hybrid planning concrete and analytically actionable, rather than rhetorical. Planners working in hybrid governance structures may use 15-minute catchment demographic analysis as an early-stage programming tool to identify possible facility–demographic mismatches before major capital commitments are made.

The research is motivated by the planning challenges of East Asian port cities such as Busan, where aging populations, income diversity, and the coexistence of resident and tourist user bases create programming contexts that differ substantially from the North American precedents that dominate the revitalization literature. This is not a limitation to be resolved by adding more North American cases, but a structural feature of the procedure's intended use: it is designed to be re-run with local catchment and facility data in each new context, rather than to export fixed demographic–facility correspondences from this study's four cases.

Busan North Port illustrates why such a procedure is needed now. The Phase 1 redevelopment, covering roughly 1.5 million m² of former general-cargo piers adjacent to Busan Station, completed site preparation at the end of 2022 and has since moved into the stage at which parcels are disposed of and facilities are programmed (MOF 2022). Progress at this stage has been uneven: as of 2025 the landmark parcel had repeatedly failed to attract a buyer, only about a third of the saleable land had been sold, and the opera house was approximately 60% complete with completion targeted for 2026, while Phase 2 (2020–2030 project period) had passed its preliminary feasibility review in 2022 but was not expected to begin construction before 2028 (Busan Ilbo 2025). In other words, the decisions this paper addresses — what program types to emphasize, and for whom — are being made at North Port at present, largely without a systematic reading of the surrounding population. The

demographic profile of that population is distinctive. Dong-gu and Jung-gu, the two districts that adjoin the Phase 1 site, are among the oldest in Busan: more than 30% of their residents were aged 65 or over as of November 2025, against a citywide share of 24.7% that is itself the highest among Korea's metropolitan cities (MOIS 2025). Busan also records the highest rate of basic livelihood security recipients among Korea's metropolitan cities (7.1% in 2023; MOHW 2024), and the inner-city districts around the old port are generally characterized by small-scale self-employment and lower household incomes than the city's eastern districts. At the same time, the site adjoins the international passenger and cruise terminal and the main railway station, so that — as at Pier 39 — a resident catchment that is aging and modest in income coexists with a large, transient, higher-spending visitor flow.

Read against the four cases, this profile points to three implications. First, the North Port catchment resembles none of the cases exactly, but it is closest to the income-diverse, multi-generational, tourism-integrated condition of Pier 39, and furthest from the high-income professional condition of Pier 17. The cases therefore caution against importing a premium, table-service-dining-led model of the Pier 17 type, and suggest instead a balanced four-category mix in which affordable counter-service dining and multi-generational recreation carry a substantial share of programmable area. Second, the Two Bridges finding at Pier 17 is directly relevant: where a catchment is polarized between existing lower-income residents and anticipated higher-income newcomers or visitors, facility mix tends to follow the dominant spending segment, and the existing residents go unserved. At North Port, where new residential and business development will sit beside long-established aging neighborhoods, this outcome is a foreseeable risk rather than a hypothetical one, and programming for the existing residents of Dong-gu and Jung-gu — low-cost dining, everyday retail, and age-friendly recreational and cultural space — needs to be an explicit allocation rather than a residual. Third, the planned office and business functions of the redevelopment imply a daytime worker population not captured by resident statistics; the vendor-format counter-service dining of Pier 57 New York, positioned on the main circulation route, offers a relevant precedent for serving that demand without displacing resident-oriented program. The procedure described in Section 3 can be re-run for North Port with census output-area data from the Statistical Geographic Information Service (Statistics Korea 2025), and doing so before the remaining parcels are disposed of would allow facility–demographic mismatches to be identified while they can still be corrected at low cost.

Applied to North Port, the procedure would proceed in four steps. First, the catchment is defined as the census output areas (집계구) whose centroids lie within 1,200 m of the principal public entrances of the Phase 1 waterfront, using SGIS boundaries, and profiled by ten-year age cohort, household income bracket, and occupation from the Population and Housing Census (Statistics Korea 2025); because the resident base is small and polarized, the share of households below the city median and the share of residents aged 65 and over are reported alongside the catchment medians, as in Tables 3 and 4. Second, the daytime population is added from the Census on Establishments for the same output areas, and the visitor base from cruise-terminal and Busan Station passenger counts, giving the three user groups — residents, workers, visitors — in comparable units. Third, the resulting profile is read against Table 6: on present evidence it falls between the Pier 39 and Pier 57 New York conditions, which points to a program in which counter-service dining and everyday retail together, and recreational and public space, each carry on the order of a quarter to a third of programmable area, table-service dining is held well below the Pier 17 level, and a stated share of area is reserved for resident-oriented uses before the remaining parcels are allocated. These ranges are illustrative starting points drawn from four cases, not standards. Fourth, once facilities open, the same catchment is re-profiled and visitor origins are observed directly, so that the provisional allocation can be corrected; the procedure is designed as a loop rather than a one-time prescription.

Several directions follow. The most immediate is to extend the case base to Asian piers, where the demographic conditions that motivate this study are present, and to apply the procedure prospectively to North Port so that its predictions can be tested against post-occupancy observation. Three methodological improvements would strengthen the procedure itself: replacing the Euclidean catchment with a street-network isochrone; adding workplace population from origin–destination employment statistics, so that the daytime user base implied by office-heavy contexts such as Pier 57 New York is measured rather than inferred; and using mobile-phone origin–destination data to observe visitor origins directly, which would allow the visitor-orientation dimension to be measured rather than proxied by online visibility. A companion study of the same four piers addresses the complementary question of where facilities are placed within the pier structure, using configurational analysis of circulation and depth; linking that analysis to the demographic profiling reported here would turn the present procedure, which answers what to program, into one that also answers where. More broadly, this study advances a research agenda for user-centered waterfront design that repositions demographic analysis, long established in retail planning, as a useful supplementary instrument for the growing global practice of industrial pier revitalization.

APPENDIX

Table 7 lists the census tracts that constitute each 15-minute catchment, with their 2019–2023 ACS population and median household income.

Pier	Census tract (GEOID)	Population	Median household income (US\$)
Pier 17 (NY)	36061000700	9,008	197,058

Pier 17 (NY)	36061000800	8,889	33,953
Pier 17 (NY)	36061000900	1,860	222,237
Pier 17 (NY)	36061001300	5,371	193,984
Pier 17 (NY)	36061001501	7,777	123,750
Pier 17 (NY)	36061001502	8,485	182,348
Pier 17 (NY)	36061002100	7,944	250,000+
Pier 17 (NY)	36061002500	5,070	23,737
Pier 17 (NY)	36061002700	1,191	135,000
Pier 17 (NY)	36061002901 ^a 36061002901	789	11,612
Pier 17 (NY)	36061002902	3,832	n/a ^b n/a
Pier 17 (NY)	36061003100	2,770	225,694
Pier 57 (NY)	36061007100	5,364	167,963
Pier 57 (NY)	36061007300	5,744	170,434
Pier 57 (NY)	36061007500	3,814	157,350
Pier 57 (NY)	36061007700	5,584	170,655
Pier 57 (NY)	36061007900	4,514	159,763
Pier 57 (NY)	36061008100	6,331	161,474
Pier 57 (NY)	36061008300	3,629	79,036
Pier 57 (NY)	36061008700	5,712	147,454
Pier 57 (NY)	36061008900	5,849	98,952
Pier 57 (NY)	36061009100	6,445	188,145
Pier 57 (NY)	36061009300	9,699	105,682
Pier 57 (NY)	36061009700	4,477	70,816
Pier 57 (NY)	36061009901	1,884	250,000+
Pier 57 (Seattle)	53033007202	3,631	170,700
Pier 57 (Seattle)	53033008002	4,363	121,341
Pier 57 (Seattle)	53033008101	2,788	118,657
Pier 57 (Seattle)	53033008102	3,512	145,642
Pier 57 (Seattle)	53033008200	4,632	135,931
Pier 57 (Seattle)	53033008300	3,342	92,969
Pier 57 (Seattle)	53033009200	3,373	39,117
Pier 39 (SF)	06075010101	2,004	101,974
Pier 39 (SF)	06075010102	1,795	108,417
Pier 39 (SF)	06075010202	1,761	206,484
Pier 39 (SF)	06075010300	3,791	158,973
Pier 39 (SF)	06075010401	2,393	207,500
Pier 39 (SF)	06075010402	2,012	158,500
Pier 39 (SF)	06075010600	3,293	86,111
Pier 39 (SF)	06075010702	1,380	80,472

Table 7 Census tracts constituting each 15-minute catchment (ACS 2019–2023 five-year estimates; median household income from table B19013, top-coded at \$250,000)

^a Tract 36061002901 (Civic Center) is dominated by institutional group quarters and contains only 79 households. ^b Median household income for tract 36061002902 is not published in the ACS because the sample is too small for a reliable estimate; the tract's households (1,893) are nevertheless included in the catchment income distribution through table B19001.

Table 8 reports, for each pier, the estimated programmable floor area, the area and share of each facility category, and the facilities with their estimated areas and classification. Category totals are CAD-traced polygons on the source plans (± 10 –15% per facility); individual areas are given where a facility was traced separately. Tenant names are those identified for the 2024 survey date from operator directories and press coverage, and unit-to-tenant assignment is stated where the plan position makes it unambiguous.

Pier / facility	Category	Units	Est. area (m ²)	Share (%)	Note (source, classification)
Pier 17, New York — programmable area			3,046	100	Ground level; source plan SHoP Architects (2024)
Table-service restaurants: The Fulton, Carne Mare, Malibu Farm (closed Jan. 2024), former Ssām Bar and Bar Wayō units (closed 2023)	Table-service	5	2,840 (indoor 1,855; attached outdoor terraces 987)	93	Ground-floor plan, SHoP Architects; tenants from Seaport directory and press; bar areas within restaurants counted as table-service
Mister Dips	Counter-service	1	206	7	Fast-casual counter unit; directory
Excluded: broadcast studio/office, promenade furniture, Clipper City sailing boat, upper-level event floors and rooftop venue	—	—	—	—	Non-public or circulation (Section 3.4)
Pier 57, New York — programmable area			3,659	100	Ground level; source plan Pier 57 NYC (2024)

City Winery (restaurant, tasting room and music venue)	Table-service	1	1,420	39	Operator directory; 32,000 sq ft lease includes production and back-of-house not traced
Table-service restaurant unit adjoining Market 57	Table-service	1	362	10	Plan legend; tenant at survey date not identified in public directories
Market 57 food hall kiosks (K1–K17 numbering; 15 traced): Al Volo, Zaab Zaab, Little Banchan Shop, Glizzy's, Bessou, LoLo's, Nom Wah, Shawarma & Co., Ammi, Essex Pearl, Bird & Branch, Harlem Hops, JBF Good to Go, and two further kiosks	Counter-service	15	746	20	Kiosk footprints only; Market 57 is a 16,000 sq ft hall whose shared seating is the Living Room (below)
Living Room (free indoor public space, 7,400 sq ft reported)	Public space	1	589	16	Classified as public space per operator; also used as Market 57 seating; traced area below reported figure
Community Classrooms (Daffodil, Seahorse, Oyster) and Discovery Tank interactive gallery	Education	3	541	15	Hudson River Park Trust spaces; plan legend 'classroom and interactive gallery'
Excluded: rooftop park (c. 0.8 ha, open parkland), upper-floor offices, river-end unit vacant at survey (318 m²; opened 2025 as El Bar, 3,000 sq ft), PLATFORM by JBF show kitchen (within Market 57, not separately drawn)	—	—	—	—	Section 3.4 conventions
Pier 57, Seattle — programmable area			2,562	100	Single level; source plan Miners Landing (2024)
Table-service restaurants: The Crab Pot (at the entrance), The Fisherman's Restaurant & Bar (west, beside the Great Wheel), and two smaller units	Table-service	4	1,399	55	Miners Landing directory; bar counted as table-service; seasonal upper-floor food court not drawn
Counter-service kiosks: The Salmon Cooker, Alaskan Sourdough Bakery, Seattle Bay Creamery and three kiosks	Counter-service	6	249	10	Directory; entrance promenade
Pirates' Plunder gift shop	Retail	1	115	5	Directory
Klondike Arcade, historic carousel and Wings Over Washington	Recreation	3	347	14	Plan legend 'arcade & merry-go-round'
Seattle Great Wheel (operated footprint)	Recreation	1	113	4	Open-air ticketed attraction; footprint only
Salish Sea Tours boat berth	Recreation	1	338	13	Open-air ticketed attraction; berth footprint measured on the published plan
Excluded: toilets, promenade	—	—	—	—	Circulation
Pier 39, San Francisco — programmable area			21,867	100	Ground and first levels; source plan Pier 39 (2024)
Table-service restaurants (16): Bubba Gump Shrimp Co., Crab House, Eagle Cafe, Fire & Ice, Fog Harbor Fish House, Hard Rock Cafe, Luau Lounge, Pier Market Seafood, Players Sports Grill, Swiss Louis, Wipeout Bar & Grill, Humble Sea Brewing and others	Table-service	16	5,913	27	Pier 39 directory; both levels
Counter-service outlets (9): Chowders, Boudin Bakery Cafe, Crepe Cafe, Fun Food Factory, Taco Cantina and smaller stands	Counter-service	9	812	4	Directory; small carts and coffee stands not traced
Retail shops (52, incl. Build-A-Bear Workshop, Alcatraz Gift Shop, Lids, Sunglass Hut, Na Hoku, Pearl Factory, The Cable Car Store, Krazy Kaps, Magnetron)	Retail	52	8,362	38	Directory; both levels
Aquarium of the Bay (two levels)	Recreation	2	4,075	19	Ticketed attraction
Sea lion docks (K-Dock) and viewing area	Recreation	2	1,388	6	Open-air; operated viewing footprint measured on the published plan
The Flyer (flight ride), 7D Experience, Magowan's Infinite Mirror Maze, San Francisco Carousel	Recreation	4	1,311 (532, 369, 205, 205)	6	Ticketed attractions
Excluded: marina berths, circulation decks, stairs, toilets, lobbies	—	—	—	—	Section 3.4 conventions

Table 8 Facility inventory, estimated floor areas, and classification for each case study pier

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