

Article

Smart Adaptive Reuse of Vacant Assets for Aging Societies: Integrating IoT-Based Care Systems with Spatial Reconfiguration

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Abstract

South Korea faces a “twin crisis” of a super-aged society and urban vacancies, yet traditional adaptive reuse focusing on physical renovation fails to address the critical caregiver shortage. To resolve this, the study proposes a “Smart Adaptive Reuse Model” that fuses spatial reconfiguration with IoT-based care technologies. A comparative analysis of Japanese cases was conducted using two datasets: the “physical-centric phase” (dataset A, pre-2015), focused on hardware improvements, and the “tech-enabled phases” (dataset B, 2020–2024), which utilized digital transformation strategies. Results indicate that while early models struggled with the surveillance of blind spots in complex layouts, recent tech-integrated models successfully mitigated these issues and improved workforce efficiency through “data-driven layouts” without major structural changes. Consequently, this research suggests a “Hybrid Retrofit” framework strategy for Korea—minimizing physical intervention while maximizing digital monitoring—and recommends a regulatory sandbox for “Smart Care Infrastructure” to ensure operational sustainability.

Keywords: adaptive reuse; smart community care; hybrid retrofit; urban vacancy; gerontechnology

1. Introduction

1.1. Background: The Twin Crisis of a Super-Aged Society and Urban Vacancy

South Korea is currently confronting a “twin crisis” characterized by an unprecedentedly rapid transition into a super-aged society, concurrent with a surge in urban vacancies resulting from a shrinking school-age population and the decline of old towns in the city [1,2]. While past urban planning paradigms were predicated on population growth and spatial expansion, the current imperative—amidst a contracting demographic structure—shifts toward the strategic repurposing of existing infrastructure. In particular, functionally obsolete urban assets, such as closed schools, antiquated government buildings, aging hospitals, and vacant commercial spaces, are increasingly garnering attention as potential resources capable of absorbing the escalating demand for elderly care.

However, the mere acquisition of physical space is insufficient to resolve this systemic issue. This insufficiency stems from a deepening “care deficit,” [3] a phenomenon wherein the supply of human capital—specifically, caregiving personnel—fails to keep pace with the rapid growth of the elderly population. Consequently, the utilization of urban vacancies necessitates a sustainable operational model that transcends mere Physical Adaptive Reuse to actively mitigate the critical shortage of care labor [4–6].



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1.2. Problem Statement: Limitations of Physical Renovation Amid Caregiver Shortages

Traditionally, adaptive reuse strategies have predominantly focused on enhancing the physical performance of existing structures. Key interventions have centered on seismic retrofitting, thermal insulation improvements, and barrier-free design implementation. This approach mirrors the methodology adapted in Japan during the 2000s, which successfully contributed to securing spatial safety and accessibility [7,8].

However, such physical renovation reveals critical limitations in the face of chronic workforce shortage. The structural characteristics of typical conversion targets—such as closed schools, aging resorts, and former hospitals—often feature long corridors and numerous compartmentalized rooms. These spatial configurations inevitably elongate caregiver workflows and create surveillance blind spots. In the current reality where a limited number of staff must care for a large number of elderly residents, this spatial inefficiency significantly degrades operational productivity and impedes immediate responses to safety incidents, such as falls.

Ultimately, improvements to the “hardware” (physical space) alone cannot prevent the qualitative decline of “software” (care services) or curb rising operational costs. It is now imperative to move beyond mere spatial refurbishment and integrate technological interventions that enable safe and efficient facility operation, even with a reduced workforce.

1.3. Research Objective: Proposing a Tech-Integrated Adaptive Reuse Model

This study begins with a critical inquiry: How can urban assets, characterized by inherent structural constraints, such as long corridors and rigid partitioning, be effectively repurposed for elderly care amidst a critical shortage of caregiving labor? To address this, the objective of this study is to propose a “tech-integrated adaptive reuse model” tailored to the Korean context by analyzing cutting-edge case studies from Japan, a nation proactively responding to the challenges of a super-aged society. To this end, this research conducts a comparative analysis of the evolutionary trajectory of Japan’s approach, tracing the shift from physical facility improvement (Phase 1) to IoT and data-driven operational optimization (Phase 2). Specifically, through an examination of key cases such as Sompō Care and the Urban Renaissance Agency (UR), this study seeks to elucidate how digital technologies are being leveraged to overcome inherent physical spatial limitations. Ultimately, by presenting a “Hybrid Retrofit Framework Model” that integrates spatial retrofitting with digital transformation, this research aims to bridge the gap between architectural adaptation and smart healthcare management. The proposed framework envisions these underutilized assets not merely as elderly care facilities but as Smart Care hubs that ensure both workforce efficiency and residential safety.

2. Theoretical Framework

2.1. Concept of Adaptive Reuse in Social Welfare Facilities

‘Adaptive Reuse’ refers to a sustainable architectural strategy wherein functionally obsolete or deteriorated structures are not demolished but are instead repurposed to meet contemporary needs, thereby extending their building lifecycles. From the perspective of urban regeneration, this process is defined as more than the mere physical preservation of buildings; it is a strategic mechanism for enhancing operational sustainability and community resilience, extending beyond mere physical preservation [5,9]. While Plevoets and Van Cleempoel’s research has extensively categorized reuse strategies mainly focusing on heritage conservation [4], this study extends the scope to non-heritage ordinary urban assets.

In particular, vacant schools, aging buildings, empty commercial spaces, dilapidated resorts, and former hospitals have been identified as optimal candidates for conversion

into social welfare and elderly care facilities. These structures typically possess inherent advantages for collective housing and care service delivery, such as strategic locations within the community core that ensure excellent accessibility, as well as wide corridors and numerous portioned rooms suitable for residential accommodation.

However, traditional theories of adaptive reuse have predominantly concentrated on “hardware performance enhancement,” such as structural reinforcement, energy efficiency improvement, and the implementation of barrier-free design [10]. To address this limitation, this study proposes a theoretical expansion from ‘Physical Adaptive Reuse’ to ‘Systemic Adaptive Reuse.’ We define Systemic Adaptive Reuse as an approach where the sustainability of a repurposed building is not determined solely by its structural integrity (hardware) but by its capacity to embed digital care infrastructure (software integration). While traditional theories—such as Bullen and Love’s work on economic viability—focus on the static preservation of the asset, Systemic Adaptive Reuse focuses on the dynamic continuity of service delivery. In a super-aged society facing a ‘care deficit,’ we argue that a building without this integrated software is functionally obsolete, regardless of its physical condition.

2.2. Evolution of Care Models: From Institutional Care to Smart Community Care

The paradigm of elderly care has evolved through three distinct stages, reflecting broader historical and social shifts:

- (1) Institutional care: Representing the initial stage, this model focuses on managing the elderly by isolating them in a hospital or large-scale homes. While it offers high operational efficiency, it often results in a deterioration of quality of life and leads to social disconnection [11].
- (2) Aging in place (AIP): Emerging alongside the trend of “deinstitutionalization,” this concept aims to enable individuals to live out their lives in their familiar communities [12]. This aligns with the global shift towards “deinstitutionalization” observed in Western welfare states. While Japan’s “Community-based Integrated Care System” represents a pioneering Asian model [13], the reliance on human caregivers makes it increasingly vulnerable in shrinking societies. However, as a fundamentally labor-intensive model, its sustainability is increasingly threatened in societies facing severe workforce shortages.
- (3) Smart community care: This is the currently required model, which upholds the principles of AIP while supplementing the workforce deficit through technological integration [14,15].

While past remodeling efforts were limited to creating physical environments for “institutional care” or elderly-stage “AIP”, current strategies aim to construct spaces that realize “smart community care”. This implies that physical spaces must evolve from mere “residences” into “active care platforms” where data is generated, and interactive services are delivered.

2.3. Role of IoT and AI in Gerontechnology for Aging in Place

Gerontechnology, a portmanteau of gerontology and technology, encompasses a broad range of technological interventions designed to support independent living and social participation among the elderly [16]. Within the context of adaptive reuse, the integration of IoT and AI performs critical functions, serving as a pivotal solution to overcome the inherent physical limitations of aging infrastructure [17]. First, it addresses the elimination of surveillance blind spots. Traditional building typologies such as schools, resorts, hospitals, and hotels are characterized by elongated corridors and articulated structures, which inevitably create areas beyond the direct line of sight. Motion sensors and AI-driven

computer vision technologies enable effective monitoring of these “dead zones” without the need for physical structural alteration. Second, it facilitates a paradigm shift from reactive to predictive care. Conventional nurse call systems operate as “passive defense” mechanisms, triggering a response only after an incident has occurred. Conversely, AI-based analysis of lifelog data detects deviation in behavioral patterns. This enables “active prevention” by predicting potential risks, such as falls or health deterioration, in advance, while simultaneously utilizing privacy-preserving methods [18]. Third, it enhances operational efficiency. By optimizing workforce allocation, these technologies allow for the safe and effective management of expansive underutilized spaces with minimal staffing. Consequently, this technological integration secures the economic feasibility of remodeled facilities by offsetting the costs associated with labor shortages.

Most ‘smart building’ literature focuses on new construction with optimized digital infrastructure. However, applying these technologies to ‘legacy stock’—older buildings with rigid structure and limited cabling capacity—presents unique challenges. In this context, IoT sensors act not merely as an amenity but as a compensatory mechanism for the physical deficits (e.g., blind spots, poor insulation) inherent in reused buildings.

3. Methodology

3.1. Research Scope and Comparative Approach

This study adopts a qualitative comparative case-study approach to explore viable solutions for utilizing vacant spaces. By analyzing the chronological evolution of Japanese models, the research aims to structurally verify the efficiency of ‘Tech-Integrated Adaptive Reuse’ compared to traditional physical renovation.

The spatial scope of this research is limited to elderly housing and nursing care facilities in Japan, a nation that experienced rapid population decline and urban vacancy prior to Korea. The temporal scope is divided into two distinct phases: the “Physical Transition Phase” (Phase 1: 2000–2015), characterized predominantly by hardware-centric approaches, and the “Tech-Fusion Transition Phase” (Phase 2: 2020–2024), marked by the full-scale integration of IoT and AI technologies.

The framework for comparative analysis is established across four key dimensions:

- **Spatial Strategy:** What architectural and spatial techniques were employed to overcome the physical constraints of existing buildings?
- **Operational Efficiency:** How have workforce management protocols evolved to address the critical shortage of caregiving personnel?
- **Safety Mechanism:** Has the method for ensuring resident safety shifted from reactive responses to proactive prevention?
- **Limitations and Solutions:** What were the inherent limitations of the models in each phase, and how did technology mitigate these shortcomings?

3.2. Data Collection

To ensure the objectivity of the research, data collection was dual-tracked into literature reviews and empirical case analyses, organized into two distinct datasets:

Dataset A: Physical-Centric Phase (AIJ, Pre-2015) [19]: This dataset is constructed based on literature published by the Architectural Institute of Japan (AIJ) and early guidelines from the relevant Japanese government agency, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Primary Subjects: Early conversion cases from the 2000s, where closed schools and vacant buildings were repurposed into welfare facilities, were considered primary subjects.

Key Variables: Data collection focused on the physical environment, including the status of seismic retrofitting, installation of fire safety equipment, and specific renovation details (e.g., expansion, reduction, or repair).

Dataset B: Tech-Enabled Operation Cases (2020–2024): This dataset is derived from empirical data provided by leading enterprises and institutions that have currently integrated Smart Care technologies to optimize operations.

Primary Subjects: Recent cases demonstrating attempts to enhance operational efficiency through technology adoption, specifically Sampo Care in the private sector, the Urban Renaissance Agency (UR) in the public sector, and Gakken cases (PPP), were considered primary subjects.

Key Variables: Data collection focused on operational outcomes, specifically analyzing the correlation between sensor types, spatial challenge, and efficiency gains.

3.3. Analytical Framework

The analysis employs a tri-axial evaluation framework to derive structural implications:

1. **Spatial Strategy (Physical):** How structural constraints (e.g., long corridors) were managed, whether through demolition or preservation.
2. **Operational Efficiency (Process):** The shift in workforce allocation, specifically evaluating the transition from human-intensive patrols to technology-assisted monitoring.
3. **Safety Mechanism (Outcome):** The evolution of safety protocols from reactive measures (nurse calls) to proactive prevention (AI prediction).

4. The Evolution of Adaptive Reuse in Japan: A Comparative Analysis

4.1. Phase 1: Physical-Centric Renovation (Pre-2015)

4.1.1. Conversion of Vacant Buildings: Focusing on Barrier-Free Design and Seismic Retrofitting

The cases listed in Table 1 were selected from *Converting Vacant Houses and Building into Welfare Facilities: Conversion of Local Resources* (AIJ, 2014) [19]. This publication is significant as it documents successful commercialization outcomes achieved through multidisciplinary collaboration among architects, business operators, researchers, and welfare specialists.

Table 1. Summary of building conversion into welfare facilities.

No.	Case	Project Year	Location	Building Use	Conversion Welfare Use
1	Beautiful Hills	2005	Nihonmatsu	accommodation	large residential
2	Peace of mind, life longevity	2007	Ube	hospital	large residential
3	Minato Rainbow Heights	2011	Abashiri	hospital	large residential
4	Healthcare Town Nishioi	2009	Shinagawa, Tokyo	elementary school	large residential
5	Care community Harajuku Hills	1999	Shibuya, Tokyo	middle school	daycare
6	Yuwaku hoikuen	2009	Kanazawa	part of elementary school	daycare
7	Nakanobu daycare branch	2011	Shinagawa, Tokyo	part of elementary school	daycare
8	Tokyo Certified Childcare Center	2009	Tokyo	part of community center	daycare
9	Haruna-so	2006	Gunma-ken	retail store	large residential
10	Tomonoura sakura home	2004	Fukuyama	vinegar workshop	small residential
11	Chikusen	2007	Fukutsu	high-class restaurant	small and multi
12	Komoreba daycare	2011	Nagoya	store	daycare
13	Nojoenomoli living support center (daycare)	2011	Kurume	store	community cafe

Table 1. *Cont.*

No.	Case	Project Year	Location	Building Use	Conversion Welfare Use
14	Makisseukadai restaurant	2011	Sakai	store	community restaurant
15	Fureai Restaurant Akemai Himawari	2003	Hyōgo-ken	store	community restaurant
16	Living support home Chez home M	2006	Beppu	storage	small residential
17	Sekisan club	2000	Musashino	worker office	daycare
18	Palette Seiwa welfare center	2011	Osaka	office	daycare
19	Nakagome daycare and service center	2001	Saku	office	daycare
20	Toyotama Kirara living support center	2005	Nerima	office	daycare
21	Momo's house daycenter	2010	Osaka	lumber shed	daycare
22	Watabosiui House	2000	Kushiro	clinic and office	small residence, daycare
23	Jirafu Namba	2010	Osaka	rental office	daycare
24	Fuji cafe	2007	Osaka	machine warehouse	community cafe
25	Grass house	2008	Minato	office	community cafe

Source: [19] Architectural Institute of Japan (AIJ). (2014) *Converting vacant empty houses and buildings into welfare facilities: conversion of local resources*. Gakugei Publishing.

Of the original 37 cases, this study limited its scope to 25 facilities that remain operational with publicly accessible data [19]. Operational status as of July 2025 was verified through local government registries, facility websites, and press releases. One facility, currently under reconstruction due to following its initial conversion, was also included in the dataset. Table 1 compares the original building for functions with their converted welfare uses. These uses are categorized into facilities for the elderly, children, and persons with disabilities, as well as community centers. Although the primary focus is on elderly care, mixed-use facilities serving the disabled and local residents were included to reflect the increasing trend.

4.1.2. Limitations: Operational Inefficiencies and Structural Constraints

A review of Japanese cases in Table 2 reveals that while early reuse of vacant buildings contributed to physical safety, it failed to fully overcome operational inefficiencies and spatial constraints stemming from the inherent structures of the original buildings.

Table 2. Conversion details and the management sector.

No.	Conversion Type *	Management	Total Floor Area (m ²)	Building Floors	Structure **	Converting Details
1	expansion	social welfare foundation	590	5	RC	expansion of common space and corridor
2	reduction	limited liability company	1703	5	S	addition of toilet and firefighting equipment, removal of masonry wall and room units
3	expansion	social welfare foundation	923	3	S	addition of entrance and lift, system replacement
4	expansion	social welfare foundation	5053	3	RC	retrofit window and wall, out-of-frame structural reinforcement, addition of balcony, smoke exhaust equipment
5	renovation	public (Sibuya-ku, Tokyo)	3593	3	RC	addition of elevator, bathroom and day room, system replacement of toilet, space arrangement

Table 2. Cont.

No.	Conversion Type *	Management	Total Floor Area (m ²)	Building Floors	Structure **	Converting Details
6	renovation	corporation	250	1	RC	space arrangement, material replacement,
7	repairing	public (Shinagawa-ku, Tokyo)	228	1	RC	system replacement of toilet, painting interior
8	repairing	corporation	-		SRC	system replacement partially, space arrangement
9	expansion	incorporated foundation	1003	2	S	expansion of kitchen and store
10	expansion	limited liability company	474	2	W	firefighting equipment
11	repairing	social welfare foundation	624	2	W	system replacement and addition of bathroom, toilet, and BF tools
12	renovation	social welfare foundation	200	3	RC	removal of wall, addition of firefighting equipment, insulation system
13	renovation	medical corporation	146	1	S	system replacement, biotop and landscaping work
14	renovation	NPO	116	1	RC, M	addition of wall, bathroom, and BF tools
15	renovation	NPO	48	1	RC	moving wall, space arrangement
16	reduction	medical corporation	1811	2 (1)	S	heating and cooling system
17	renovation	NPO	76	2	S	heating and cooling system
18	expansion	social welfare foundation	4155	4	S	heating and cooling system
19	renovation	medical corporation	565	2	S	bathroom and kitchen system replacement
20	renovation	social welfare foundation	301	1	RC	space arrangement, garden in rooftop
21	expansion	social welfare foundation	257	3	S	heating and cooling system
22	repairing	NPO	244	2	W	system replacement of bathroom
23	renovation	social welfare foundation	112	10	SRC	soundproof
24	repairing	social welfare foundation	85	1	W	structural reinforcement, addition of opening part
25	interior	limited liability partnership	67	3	lightweight S.	space arrangement, interior work

* Conversion Type: Expansion—increase or expand the area or space of an existing building. Renovation—work to improve or repair the exterior, interior, or function of an existing building without structural changes. Repairing—restore functionality by replacing or reinforcing worn-out parts or equipment. Reduction in size—renovate and reduce the floor area or space. Interior—decorate or redesign an interior space. ** Structure: M (masonry), W (wood construction), RC (reinforced concrete structure), S (steel frame structure), SRC (steel reinforced concrete structure). Source: Based on the content of the relevant literature, AIJ (2014) [19], local government welfare facility lists, and information from official case study websites.

First, renovation without structural changes hinders the optimization of care workflows. The most prevalent conversion type was renovation, which improves internal and external conditions without altering the main structural framework. Maintaining fixed layouts—such as the long corridors typical of hotels, schools, and hospitals—or utilizing small retail spaces limits the flexibility required for modern care configurations, such as unit care systems or efficient patrol routes.

Second, space reduction during conversion can compromise capacity and profitability. Some cases experienced a decrease in floor area due to equipment replacement or partial demolition during renovation. While often an inevitable choice to comply with current regulations, this ultimately acted as a constraint by reducing the usable facility area.

Third, structural characteristics limited functional reinforcement. Structural strengthening was rare, except in wooden buildings. The absence of basements in many buildings

made expanding equipment space difficult, often confining interventions to the simple replacement of old systems (repairing). This implies a significant restriction on installing heavy modern care equipment, such as patient lifts or large bathing facilities.

Fourth, the dominance of private-sector operation hindered comprehensive structural improvements. Most operating entities were private organizations. With limited public funding available, private operations tended to rely on cost-effective measures—such as partial repairs or interior updates—rather than undertaking expensive expansions or major overhauls.

Consequently, Phase 1 demonstrates that compliance with building codes (seismic, fire safety) does not guarantee operational efficiency. The reliance on physical renovation alone failed to resolve the ‘spatial blind spots’ inherent in legacy structures, resulting in sustained high labor costs.

4.2. Phase 2: Tech-Enable Phase (2024–2025)

4.2.1. Sompo Care: Retrofitting Legacy Facilities with Real Data Platforms (RDP)

Sompo Care, Japan’s largest nursing care enterprise, operates as a specialized subsidiary under the Sompo Holdings insurance group. The company provides a comprehensive portfolio of services, including free-based nursing homes, serviced housing for the elderly, home care, and daycare [20]. As of 2023, it manages approximately 28,500 residential units and serves nearly 72,000 individuals. A distinguishing feature of Sompo Care’s business model is its transition toward a large-scale integrated operational system, achieved not by constructing new facilities, but by acquiring and streamlining existing legacy facilities [21]. This strategy prioritizes asset efficiency, enabling flexible utilization of existing stock and rapid scalability.

This case is particularly significant for its implementation of technology- and data-driven care delivery. Going beyond the mere management of physical assets, Sompo Care realizes “Smart Care” (often referred to as “Care-tech”) by integrating data analytics, digital tools, and automation technologies [22]. To empirically validate the impact of this technology, Sompo Care deployed the ‘Sleep SCAN’ system across 28,500 beds following a 2020 partnership with Paramount Bed Holdings. This system visualizes residents’ sleep, excretion, and meal patterns on a real-time dashboard, allowing staff to monitor ‘blind spots’ in complex legacy buildings without physical rounds. Quantitative data from the ‘Yasuragi no Oka’ facility in Chino City demonstrates clear efficiency gains. Comparing operational metrics before (February 2023) and after (June 2024) the system’s full integration, the total staff count decreased from 24 to 17 (a 29% reduction), while night-shift personnel and patrol frequencies both dropped by 33% (from 3 to 2). This confirms that the digital overlay structurally reduced the labor intensity required to manage the physical disadvantages of the repurposed infrastructure [23].

4.2.2. UR Urban Renaissance: IoT Monitoring Systems in Aging Housing Complexes

This case is distinguished by its transformation of aging public housing into integrational spaces through the deployment of privacy-preserving, non-contact sensors [24]. Built in the 1960s and 1970s, UR complexes faced the simultaneous aging of both physical infrastructure and the resident population [25]. To address these dual challenges, UR collaborated with private enterprises to implement IoT-driven monitoring systems, prioritizing safety management without compromising resident privacy [26].

The integration of CCTV, motion sensors, and AI surveillance has effectively mitigated physical constraints, such as complex circulation paths and blind spots. The “Mimamori” sensor system utilizes non-visual sensors instead of cameras, detecting anomalies while strictly preserving resident privacy.

Alerts are automatically triggered if no movement is detected in living areas for a set period (multi-sensor detection). AI algorithms also analyze utility patterns—such as zero electricity usage or prolonged lighting at night—to verify resident well-being. Additionally, under-mattress sleep sensors monitor vital signs (heart rate, respiration) and bed occupancy. Furthermore, automated temperature and humidity management compensates for poor insulation in aging complexes, negating the need for extensive physical renovations.

Specifically, to address the chronic issue of poor insulation in aging concrete structures, UR collaborated with the Environmental Energy Research Institute and the startup ‘Momo’ to deploy an AI-driven HVAC control system at the ‘Miraie Chiryu Yamayashiki’ elderly housing in Aichi Prefecture. By utilizing predictive algorithms—such as automatically initiating pre-cooling when daytime temperatures are forecast to exceed 30 °C—the system optimized energy consumption patterns based on real-time environmental data. The pilot results demonstrated a significant reduction in power consumption: 20% in summer and 50% in winter compared to manual operation. This quantitative outcome supports the argument that ‘digital insulation’ via IoT optimization can serve as a cost-effective alternative to expensive physical insulation retrofitting, thereby justifying the adaptive reuse of older buildings over new construction [27].

Prominent examples included the Kashiwa Toyoshikida project (a collaboration between the University of Tokyo and local government) and TEPCO’s electricity data-based monitoring service [28,29]. These initiatives significantly reduced night-shift staffing needs and eliminated safety blind spots. For the Korean context, this suggests a viable model for “IoT infrastructure remodeling” in vacant apartments or aging villas, securing safety performance while minimizing structural alteration costs.

4.2.3. Gakken Cocofump: Overcoming Spatial Gaps with Smart Nursing Call Systems

Gakken Cocofump, a leading brand in elderly housing and care, operates approximately 190 facilities, aggressively expanding its supply of “Serviced Elderly Housing” by repurposing underutilized land and buildings [30,31]. In such facilities, immediate staff access is often restricted by physical layouts and workforce limitations relative to the number of residents. These delays in response to calls or emergencies (e.g., falls) can be defined as “spatial gaps,” a concept implying spatiotemporal disconnection [32,33]. These gaps are further exacerbated by dispersed zoning across floors, staff shortages during night shifts, and structural barriers such as long corridors or compartmentalized private rooms.

Smart Nurse Call is a smartphone-integrated system that enables immediate staff response regardless of location. By linking indoor positioning with bed sensors, the system identifies the caller’s exact status and location, automatically routing notifications to the nearest available caregiver [30]. Cloud-based analysis of mobile call logs accumulates data on response times, frequency, and locations to identify vulnerable zones. This data informs optimization strategies for patrols, staffing, and facility upgrades, with related studies confirming significant reductions in response times and fall incidents [34].

Furthermore, Gakken’s collaboration with Panasonic demonstrates how tech integration expands the scope of care from individual rooms to the entire community. Since 2016 at ‘Fujisawa Sustainable Smart Town (SST),’ the adoption of the ‘Mimamori Air Conditioner’ system has allowed for the collection of resident activity data and automated temperature control using existing HVAC units without requiring additional piping work. This offers high applicability for retrofitting vacant buildings where minimizing structural intervention is crucial. More recently, in 2022, at ‘Cocofump Suita SST,’ the integration of AI-driven 4K cameras extended this safety net to outdoor areas. By detecting falls or wandering in real-time across the town without physical barriers, the system enables residents with cognitive impairments to move freely. This implies that for adaptive reuse projects involv-

ing complex historical landscapes or outdoor structures where installing physical gates is challenging, ‘virtual gating’ via facial recognition can secure safety while preserving the site’s original context [35]. This highlights the potential of mobile-linked communication technologies to resolve the “spatial gap” issues inherent in converting large-scale structures with extended circulation paths, such as schools or office buildings, into welfare facilities.

Table 3 presents a comparative analysis of the preceding cases, demonstrating that tech-integrated care can enhance operational efficiency even in existing urban buildings requiring adaptive reuse, ultimately providing a stable environment for the elderly.

Table 3. Comparative analysis of tech-enabled operation cases.

Case	Key Technology (Hardware/Software)	Spatial Challenge Addressed	Operational Outcome
Sompo Care	Real Data Platform Sleep sensors (vital signs), Data integration dashboard	Surveillance Blind Spots Difficult to monitor private rooms continuously without intrusion	Optimized Staffing Reduced dependency on night patrols; shift from reactive to predictive care
UR Urban Renaissance	Mimamori Sensor System Non-contact motion sensors, Utility usage analysis	Aging Infrastructure Lack of barrier-free design in old housing complexes	Privacy-Preserving Safety Anomaly detection without cameras; sustainable residency for the elderly
Gakken Cocofump	Smart Nurse Call Bluetooth positioning, Smartphone linkage	Spatial Gaps (long corridors) Delayed staff response due to dispersed layouts	Response Efficiency Real-time location tracking; reduced response time to falls/accidents

5. Discussion: Proposal for Smart Adaptive Reuse Model

5.1. Synthesis: Shift from Hard Infrastructure to Soft and Smart Infrastructure

The transition observed from Phase 1 to Phase 2 implies a fundamental paradigm shift in defining ‘renovation.’ As analyzed in Section 4, whereas Phase 1 focused on ‘adapting the building structure to the code’ (seismic, fire safety), Phase 2 prioritized ‘adapting the operation to the user’ through digital overlays. This distinction is critical for Korea. The Japanese experience suggests that when physical alteration is cost-prohibitive due to structural rigidity, ‘digital retrofitting’ serves as the most viable alternative to neutralize spatial deficits. This necessitates a strategic framework that combines these approaches, rather than viewing them as separate phases (Table 4).

Table 4. Comparative synthesis: shift from physical-centric to tech-integrated adaptive reuse.

Category	Phase 1 Physical-Centric Renovation	Phase 2 Tech-Enable Phase
Goals	Securing space (seismic design, fire safety, barrier-free)	Operational Sustainability (labor reduction, data care)
Limitations	Long movement paths, blind spots, inefficient workforce management	Initial technology implementation costs (however, long-term operational cost savings)
Disaster safety	Passive defense, such as sprinklers, firewalls	Active prevention, such as sensor detection, AI prediction
Implication for Korea	Need for relaxation of hardware remodeling regulations	Need to establish smart remodeling guidelines and technology subsidies

5.2. Critical Assessment: Potentials and Limitations of Corporate Data

While the Phase 2 cases demonstrate a clear shift toward tech-integrated efficiency, a critical interrogation of the data source is necessary. Much of the reported efficiency gains are derived from corporate white papers and project reports, which tend to highlight best-case scenarios.

First, the ‘reduction in labor’ claimed by systems like Sompō Care must be scrutinized to ensure it does not equate to ‘reduction in care quality’. Excessive reliance on monitoring sensors may lead to ‘alarm fatigue’ for caregivers or reduce essential emotional interactions with the elderly. Second, the sustainability of these systems in the public sector remains unverified. Unlike private enterprises (Sompō, Gakken, Tokyo, Japan) that can absorb initial high capital expenditure for long-term operating expenditure savings, public adaptive reuse projects often face rigid budget constraints. Therefore, while the technological model is proven, the economic applicability to publicly funded reuse projects requires further longitudinal validation.

5.3. Strategic Framework: The “Hybrid Retrofit” Approach (Spatial + Digital)

Based on the implications derived from the Japanese case analysis, this study proposes a “Smart Adaptive Reuse Mode” to address Korea’s dual challenge of a super-aged society and urban vacancies. The core of this proposal is a “Hybrid Retrofit” strategy, designed to bypass the operational limitations experienced in Japan’s Phase 1 and leapfrog directly into the tech-integrated Phase 2.

Expansion of elderly welfare facilities in Korea must be pursued through this hybrid approach, which simultaneously integrates physical hardware improvements with digital software solutions. The two-pillar strategies are defined as follows.

- **Minimum Physical Intervention:** This strategy minimizes construction costs and duration by preserving the existing structural framework, such as columns and stairwells, to the greatest extent possible. However, essential physical safety standards, including barrier-free design and seismic retrofitting, are strictly maintained at the level of Japan’s Phase 1.
- **Maximum Digital Intervention:** This strategy addresses structural issues—such as inefficient circulation paths and surveillance blind spots that are difficult to resolve physically—by deploying IoT sensors and AI monitoring systems instead of demolition. The ultimate goal extends beyond prolonging building lifespans to ensuring **operational sustainability** by maximizing the workflow efficiency of the care workforce.

As conceptualized in Figure 1, this model operated as a systemic cycle. The ‘Input’ phase categorized diverse vacant asset typologies (e.g., school, commercial stores), while the ‘Process’ phase hybridized spatial reconfiguration with IoT intervention. Consequently, the ‘Output’ achieves not only physical safety but also ‘Operational Sustainability’, defined by reduced labor dependency and enhanced emergency response capabilities.

Critically, as pointed out by the limitations of physical-centric models, not all vacant assets are suitable for conversion. Therefore, a sustainability assessment protocol determines the degree of intervention required. For example, open-plan offices require high-level partitioning intervention, whereas former hospitals may require low-level system upgrades. If the structural adaptation cost exceeds that of new construction, the asset is deemed unsuitable for this Hybrid Retrofit model.

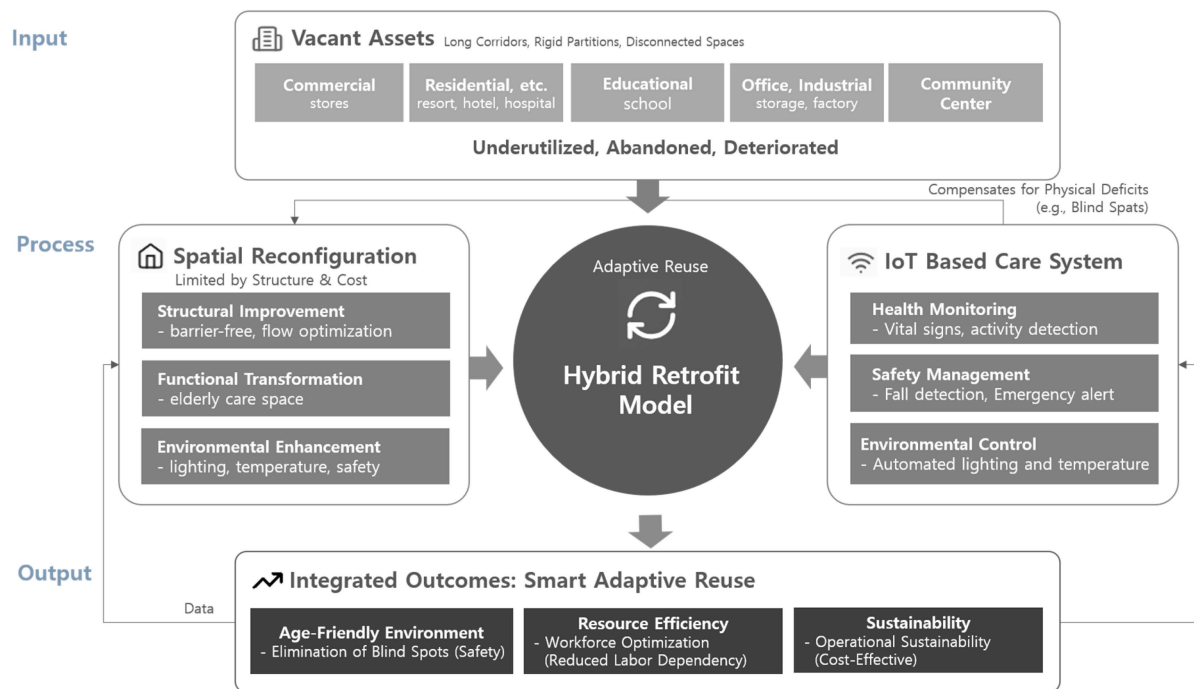


Figure 1. Hybrid Retrofit conceptual framework.

5.4. Design Guidelines: Integrating Sensors into Spatial Reconfiguration

5.4.1. Corridor and Compartment Typologies (Hotels, Schools, Hospitals)

Existing typologies characterized by long single- or double-loaded corridors and enclosed compartments increase caregiver fatigue and delay the detection of incidents such as falls. To mitigate these structural inefficiencies, intelligent CCTV systems should be deployed at key nodes—corridors, restrooms, and entrances—to automate the detection of wandering and falls. Simultaneously, privacy-preserving non-contact radar sensors should be installed within private rooms to transmit real-time data on vital signs (respiration, heart rate) and motion to the control center. By adopting the Gakken Smart Nurse Call model, this approach enhances response speeds while reducing the dependency on manual patrols.

5.4.2. Open-Plan Typologies (Commercial, Offices, Warehouses)

Column-based open plans offer a visibility advantage but pose challenges regarding privacy and acoustic management. To address this, spatial subdivision can be achieved using “Smart Wall” modules—partition walls with integrated wiring and embedded sensors. Furthermore, in open communal areas, automated ventilation systems linked to environmental sensors (monitoring temperature, humidity, and CO₂) should be established. This creates an infection-safe care environment, which is critical for the vulnerable elderly population.

5.5. Policy Recommendations: Regulatory Sandboxes and Smart Infrastructure Support

Flexible application of existing architectural and welfare regulations is essential to anchor the proposed tech-integrated model.

First, a ‘Smart Care Infrastructure Regulatory Sandbox’ should be established based on a Public–Private Partnership (PPP) governance model. Just as the UR agency in Japan collaborated with private tech firms, Korean municipalities should facilitate testbeds where private enterprises can deploy solutions. Within this framework, current staffing standards (2.3–2.5 elderly persons per caregiver) must transition from a purely physical headcount-

based metric to a “technology-assisted workforce standard”. Facilities adopting proven smart monitoring systems, as evidenced by the Sompō Care case, should be eligible for incentives such as relaxed night-shift staffing requirements or additional reimbursement rates. Given the rapid aging of Korea’s own caregiving workforce, such regulatory adjustments are urgent.

Second, the “Green Remodeling” initiative should be integrated with the “Digital New Deal”. Current Green Remodeling projects are predominantly focused on energy efficiency. Expanding the scope to include welfare facilities and establishing specific funding channels for digital transformation costs would yield significant improvements in public service delivery.

6. Conclusions

To address the dual challenges of rapid population aging and the proliferation of urban vacancies in Korea, this study analyzed Japanese adaptive reuse cases. The findings confirm that Japan’s approach is evolving from an initial focus on physical renovation toward a “Tech-Integrated Model” combining IoT and data. This shift aims to systematically overcome the operational limitations—such as inefficient circulation, spatial constraints, and workforce shortages—encountered in the earlier physical-centric phase. This research concludes that the definition of renovation in a super-aged society must expand from ‘repairing space’ to ‘installing intelligence’. This paradigm shift is not merely a technological option but a prerequisite for maintaining the social welfare system under severe demographic constraints.

The significance of the proposed “Smart Adaptive Reuse Model” lies in its capacity to transcend the mere recycling of obsolete structures, offering a sustainable care solution for a super-aged society amidst a critical labor shortage. In particular, the “Hybrid Retrofit” strategy, derived from the Japanese experience, serves as a practical guideline for Korean local governments and operating entities currently facing intensifying budgetary and workforce constraints.

However, this study is limited to a qualitative comparative analysis and conceptual modeling. Future research must undertake a quantitative validation of the proposed Hybrid Retrofit model. Specifically, a longitudinal cost–benefit analysis is required to measure the actual reduction in labor costs versus the initial capital expenditure of IoT installation, thereby proving the economic feasibility of the model.

Ultimately, it is anticipated that integrating smart technologies with underutilized community assets will revitalize vacant buildings, transforming them into safe sanctuaries for the elderly and dynamic hubs for local regeneration.

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References

1. KOSIS. Population of Elderly. Available online: <https://kosis.kr/search/search.do?query=%EB%85%B8%EC%9D%B8%EC%9D%B8%EA%B5%AC> (accessed on 1 September 2025).
2. Cho, Y.J.; Park, J.H.; Nam, K.C. How Many Vacant Buildings Are There in Korea? In *Estimating Vacant Buildings Based on Administrative Data*; AURI Brief No. 285; Architecture & Urban Research Institute (AURI): Sejong, Republic of Korea, 2024.
3. Hochschild, A.R. The culture of politics: Traditional, postmodern, cold-modern, and warm-modern ideals of care. *Soc. Politics* **1995**, *2*, 331–346. [CrossRef]
4. Plevvoets, B.; Van Cleempoel, K. Adaptive reuse as a strategy towards conservation of cultural heritage: A literature review. *WIT Trans. Built Environ.* **2011**, *118*, 155–164. [CrossRef]
5. Yung, E.H.K.; Chan, E.H.W. Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities. *Habitat Int.* **2012**, *36*, 352–361. [CrossRef]
6. Blackman, S.; Matlo, C.; Bobrovitskiy, C.; Waldoch, A.; Fang, M.; Jackson, P.; Mihailidis, A.; Nygård, L.; Astell, A.; Sixsmith, A. Ambient assisted living technologies for aging well: A scoping review. *J. Intell. Syst.* **2016**, *25*, 55–69. [CrossRef]
7. Choi, H.W. A case study on the conversion of unused commercial building into elderly welfare facilities in small-and-medium sized Japanese cities. In Proceedings of the KIID Spring Conference, Seoul, Republic of Korea, 16 May 2015; Volume 17, pp. 273–276.
8. Cho, S.H. Japan’s policy responses to municipalities at risk of extinction. *Glob. Soc. Secur. Rev.* **2024**, *31*, 101–113.
9. Douglas, J. *Building Adaptation*, 2nd ed.; Butterworth-Heinemann: Oxford, UK, 2006.
10. GhaffarianHoseini, A.; Dahlan, N.D.; Berardi, U.; GhaffarianHoseini, A.; Makaremi, N.; GhaffarianHoseini, M. Sustainable energy performances of green buildings: A review of current theories, implementations and challenges. *Renew. Sustain. Energy Rev.* **2013**, *25*, 1–17. [CrossRef]
11. Kane, R.A. Long-term care and a good quality of life: Bringing them closer together. *Gerontologist* **2001**, *41*, 293–304. [CrossRef] [PubMed]
12. Wiles, J.L.; Leibing, A.; Guberman, N.; Reeve, J.; Allen, R.E.S. The meaning of “aging in place” to older people. *Gerontologist* **2012**, *52*, 357–366. [CrossRef]
13. Tsutsui, T.; Muramatsu, N. Care-needs certification in the long-term care insurance system of Japan. *J. Am. Geriatr. Soc.* **2005**, *53*, 522–527. [CrossRef]
14. Bibri, S.E.; Krogstie, J. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustain. Cities Soc.* **2017**, *31*, 183–212. [CrossRef]
15. Demiris, G.; Hensel, B.K. Technologies for an aging society: A systematic review of “smart home” health applications. *Yearb. Med. Inform.* **2008**, *17*, 33–40. [CrossRef]
16. Bouma, H.; Fozard, J.L.; Bouwhuis, D.G.; Taipale, V. Gerontechnology in perspective. *Gerontechnology* **2007**, *6*, 190–216. [CrossRef]
17. Islam, M.M.; Rahaman, A.; Islam, M.R. Development of Smart Healthcare Monitoring System in IoT Environment. *Sensors* **2020**, *20*, 1855. [CrossRef] [PubMed]
18. Majumder, S.; Aghayi, E.; Noferesti, M.; Memarzadeh-Tehran, H.; Mondal, T.; Pang, Z.; Deen, M.J. Smart homes for elderly healthcare—Recent advances and research challenges. *Sensors* **2017**, *17*, 2496. [CrossRef]
19. Architectural Institute of Japan (AIJ). *Converting Vacant Houses and Buildings into Welfare Facilities: Conversion of Local Resources*; AIJ: Tokyo, Japan, 2014.
20. Sompo Holdings. Available online: <https://www.sompo-hd.com> (accessed on 16 September 2025).
21. PwC Korea. Insights Issue Brief. Available online: https://www.pwc.com/kr/ko/insights/issue-brief/samilpwc_senior-residence.pdf (accessed on 16 December 2025).
22. Korea Insurance Research Institute (KIRI). Seminar Materials. Available online: https://youtu.be/Bri_-LNks5M?si=CbGokrQOVt4kPngo (accessed on 16 September 2025).
23. Paramount Bed Co., Ltd. Utilization of Sleep Logs Reduces Average Night Patrol Frequency from 6 to 3.2 Times. Available online: <https://digitalwellbeing.paramount.co.jp/care/news/394> (accessed on 29 January 2026).
24. Urban Renaissance Agency (UR). Open Smart UR. Available online: https://www.ur-net.go.jp/rd_portal/OpenSmartUR/OpenSmartUR_index.html (accessed on 1 December 2025).
25. HUD User. Japan Case Studies. Available online: <https://www.huduser.gov/portal/sites/default/files/pdf/JapanCaseStudies.pdf> (accessed on 16 November 2025).
26. Zhang, L.; Hu, X. Analysis of the smart medical service model in super-aged society: UR agency as an example. *J. Healthc. Eng.* **2022**, *2022*, 8368057. [CrossRef]
27. Digital, X. Demonstration Experiment Utilizing AI and IoT to Reduce HVAC Costs in Nursing Care Service ‘e-ne’. Available online: <https://dcross.impress.co.jp/docs/usecase/002125.html> (accessed on 29 January 2026).
28. Supuka, J.; Tóth, A.; Balla, M. Smart environment practices in Kashiwa-No-Ha (Japan) smart city. *Acta Hort. Regiotect.* **2023**, *26*, 137–146.

29. Teng, X.; Shen, Z.; Zhang, Y.; Ueno, A.; Murata, A.; Ueno, A. Revising nursing home design standards and regulations in the context of an aging population: Insights from smart care buildings. *Front. Public Health* **2025**, *13*, 1540058. [[CrossRef](#)]
30. Gakken Cocofump. Available online: <https://cocofump.gakken.co.jp> (accessed on 1 September 2025).
31. Lee, M.-A.; Lee, Y.-S.; Park, J.; Jun, E.-J. Characteristics of service-supported housing for various vulnerable groups in Japan. *J. Korean Hous. Assoc.* **2018**, *29*, 81–94. [[CrossRef](#)]
32. Cao, W.; Dewancker, B. Interpreting spatial layouts of nursing homes based on partitioning theory. *J. Asian Archit. Build. Eng.* **2023**, *22*, 50–67. [[CrossRef](#)]
33. Ali, H.; Li, H. Use of notification and communication technology (call light systems) in nursing homes: Perspectives of staff. *JMIR Rehabil. Assist. Technol.* **2020**, *7*, e16252. [[CrossRef](#)]
34. Chuang, S.-T.; Liu, Y.-F.; Fu, Z.-X.; Liu, K.-C.; Chien, S.-H.; Lin, C.-L.; Lin, P.-Y. Application of a smart nurse call system for nursing care. *Telemed. E-Health* **2015**, *21*, 81–86. [[CrossRef](#)] [[PubMed](#)]
35. Kaden Watch. Fujisawa SST for 100 Years: Panasonic's Smart Air Conditioner 'Mimamori' Service. Available online: <https://connect.panasonic.com/jp-ja/case-studies/suitasst> (accessed on 29 January 2026).

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