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Bangkok Resilient and Regenerative City for Elders: Urban Aging in a Climate Vulnerability Megacity

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Abstract

Bangkok is faced with fast population aging and stronger climate hazards. Thailand is close to a super-aged society by 2033. Older adults in Bangkok are facing every year monsoon flooding, extreme heat. Also, Bangkok puts little investment in age-friendly infrastructure. Current frameworks include the WHO Age-Friendly Cities model. These frameworks reflect the contexts of high-income countries. However, these fail to apply principles of climate resilience or regeneration. This study finds the critical gaps in age-friendly infrastructure and services for older adults in Bangkok. Also, this study finds health impacts of flooding and extreme heat. This study observes the mechanisms for multi-sectoral collaboration that facilitate resource-efficient and age-responsive urban resilience. A mixed-methods design was utilized. Quantitative data were gathered from older adults (aged 60+) in Bangkok six districts. This study measures satisfaction within the WHO Age-Friendly domains. This study observes climate hazards exposure, resilience capacity, health outcomes. This study engages in environmental stewardship. Qualitative data consisted of in-depth interviews with older adults, key informant interviews, and a photovoice substudy. The data were analyzed through Importance-Performance Analysis, multivariate regression, and thematic analysis. Older adults in Bangkok are passive recipients of resilience. They are also active regenerative agents. They are important for keeping the city ecological functions. As Thailand gets closer to becoming super-aged, it is vital to see older adults as valuable contributors instead of just a burden for the future of climate-resilient city.

Discipline: Multidisciplinary (Urban Management, Infrastructure Engineering, Climate Science, Public Policy).

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1 Introduction

Cities are facing the problems of a fast aging population and increasing climate/environmental issues. By 2050, 2.1 billion people will have age 60 and more. Also, urban regions have problems like extreme heat, flooding, and environmental degradation (Srikolchan et al., 2025). These problems require urban strategies better than traditional resilience methods. Instead, it needs to take regenerative practices. This approach not only withstands shocks but also restores/improves ecological and social systems.

Bangkok shows this urgent situation. As Thailand's capital, Bangkok has achieved "aged society" status. More than 20% of its 5.5 million registered residents are 60 or older (DPA, 2026). Projections to 2033, Thailand will move into a super-aged society. It will have older adults 28% of its national population. This swift demographic change occurs in 17 years. This is unlike the transitions seen in developed nations. It gives rise to what researchers refer to as the "getting old before getting rich" phenomenon. The financial situation in Bangkok is critical. The funding for older adults services is only 2-5% of the annual budget. This underscores the urgent need for innovative strategies to mobilize resources (Srikolchan et al., 2025).

Thailand is ranked high in climate vulnerability ranking (Germanwatch, 2026). Bangkok is on a soft clay river delta. It is just 1.5-2m above sea level. It has many tall buildings. Also, a lot of groundwater is used. Bangkok is thus sinking (Tan, 2025; World Bank, 2025b). Bangkok normally faces flooding once a few years. Also, it is affected by rising sea levels. It also faces increasingly strong heat events. Thus, the Bangkok Metropolitan Administration (BMA) has initiated many projects. These include revitalizing the Green Bridge that connects Lumpini and Benchakitti Parks. Another project is establishing 304 cooling centers to help with the extreme heat (BMA, 2026a). Also, transit-oriented development (TOD) projects are used to improve climate adaptation (BMA, 2026b). However, it is still very much unclear if these efforts adequately address the specific vulnerabilities faced by older adults (ICLEI, 2025).

This research looks at an important missing piece in the studies about aging in cities. Many have used the World Health Organization's Age-Friendly Cities idea. However, it has not been fully explored in places with limited resources under affected by climate change. Most research involves with wealthy countries that have plenty of resources. These countries have strong welfare systems, good infrastructure, and large city budgets. However, Bangkok's situation is very different. Bangkok has a fast-growing aging population, tight budgets, and serious climate issues. This means special frameworks are needed. They must combine resilience and regenerative ideas with age-friendly development. This study also gives a proposed conceptual framework for Bangkok Resilient and Regenerative City for Elders (BRRCE) for urban aging in a climate vulnerability megacity.

2 Literature Review

There are two things many cities are facing, especially for Bangkok megacity. They are rapid population aging and accelerating climate change. This literature review evaluates the existing

body of research through urban vulnerability theory and regenerative urbanism. Thailand is transiting from an aged society to a "super-aged society," with the population of older adults (aged 60+) projected to reach 31.4% by 2042 (Phungviwatnikul & Voraprateep, 2023; Jitdorn et al., 2026; Somsopon et al., 2022; Sawangnate et al., 2022).

2.1 Climate Vulnerability Profile of the Bangkok Megacity

Bangkok's geographical location in the Chao Phraya River delta places it at the frontline of extreme climate risks, predominantly categorized into water and heat stressors.

2.1.1 Hydrological Precarity and Disasters: Flood Hazard and Cognitive/Physical Deterioration

Historically dependent on permeable floodplains and stilted, flexible architecture, Bangkok's modern shift toward Western-style paved urban development has severely compromised its natural hydrology. Bangkok's historical and geographical development has left it exposed to severe flood vectors, including monsoon deluges, flash floods, and sea-level rise (AP-TU, 2026). Over 50% of Bangkok's total area is designated as a high-flood-hazard zone. This is driven by intense seasonal rainfall, land subsidence, and inadequate drainage density (Sawangnate et al., 2022). For the elderly, floods are not just economic disruptions but physical traps; sensory and mobility limitations drastically reduce their capacity to evacuate or adapt to sudden disasters (Sawangnate et al., 2022).

Studies mapping flood exposure against the cognitive health of middle-aged and older Thai adults reveal that acute and chronic post-disaster stress induces microstructural brain changes, leading to measurable deficits in memory, calculation, and spatial orientation over time (Sun et al., 2025). The elderly face a heightened baseline risk due to pre-existing health conditions, low disaster literacy, and financial constraints, which compounds their physiological and psychological vulnerability during extreme weather events (Sun et al., 2025).

2.1.2 The Urban Heat Island (UHI) Effect Nexuses and Bio-Meteorological Stress

Bangkok faces an escalating thermal crisis, partially from global warming. Also, the rapid replacement of natural landscapes with impervious surfaces has amplified the Urban Heat Island (UHI) effect (Ashour et al., 2023). High-resolution land use modeling indicates that during the cool and dry seasons, nocturnal urban temperatures in Bangkok can soar up to 6.4°C higher than surrounding rural areas. This heat is particularly at night when the built environment releases trapped radiation. This exposes over 50% of the Bangkok population to sustained thermal stress (World Bank, 2025a).

For older adults, this thermal trajectory is hazardous. Physiological aging diminishes the body's thermoregulatory efficiency, creating a sharp spike in heat-related illnesses such as dehydration, heat exhaustion, and cardiovascular failure (Das et al., 2024). Longitudinal health assessments across Thai provinces indicate a direct correlation between ambient heat metrics

(Apparent Temperature, Humidex) and heightened psychological distress and poor self-reported mental health among the elderly (Keanjoom, et al., 2026). This biometeorological vulnerability is vastly magnified in older individuals who present limitations in Activities of Daily Living (ADL) or belong to low socioeconomic strata (Keanjoom, et al., 2026).

Physiologically, older adults are highly susceptible to heat-induced morbidity and psychological distress. Longitudinal studies show that short-term fluctuations in apparent temperature significantly exacerbate distress and diminish mental well-being in Thai older adults, with the strongest detrimental impacts felt by those who are socio-economically disadvantaged or have limitations in daily living activities.

2.2 Socio-Spatial Inequity and Informal Settlements

Climate vulnerability is not evenly distributed over Bangkok's urban landscape. It is highly spatialized and segregated. Neoliberal urban renewal and gentrification have progressively pushed low-income, marginalized communities—which feature high densities of elderly citizens—into hazardous "grey spaces" or informal settlements (Gozzoli et al., 2022).

A multinational qualitative content analysis of spatial planning instruments in Southeast Asian capitals highlights that informal housing sectors are disproportionately exposed to climate disruptions due to poor construction quality, lack of drainage infrastructure, and regulatory exclusion (Demeterova, 2026). When multi-level governance challenges occur—such as scale mismatches, ambiguous institutional responsibilities, and uneven local engagement—the elderly residing in these informal enclaves are effectively cut off from systemic disaster risk reduction networks (Demeterova, 2026).

2.3 From Resilient to Regenerative Urban Design for Elders

Traditional urban resilience focuses on resistance and recovery. It is the capacity of a city to absorb a shock (like a flood or heatwave) and bounce back to its original state. However, current climate discourse argues that bouncing back to a flawed status quo is insufficient for highly vulnerable groups.

2.3.1 Structural Limitations of Resilience

Traditional resilient city policies (RCP) focus primarily on resistance, adaptation, and bouncing back to a baseline state. While empirical evidence confirms that Bangkok's RCP interventions have successfully mitigated some immediate post-flood cognitive declines in specific urban areas (Sun et al., 2025), critics argue that conventional resilience frameworks are fundamentally bounded. They often fail to tackle entrenched socio-spatial injustices or actively restore degraded ecosystems (GCA, 2020).

2.3.2 Empowering Communities through Regenerative Frameworks

Regenerative urbanism shifts the focus from "doing less harm" to actively renewing, healing, and co-evolving human societies alongside natural systems. For an aging megacity, this approach

demands a blend of Nature-Based Solutions (NbS) (Abdul Rauf et al., 2026) and highly participatory, community-driven social infrastructure .

Nature-Based Solutions (NbS): Expanding urban canopy cover, constructing daylighted wetlands, and introducing pocket parks mitigate heat stress and control stormwater while offering age-friendly, accessible green public domains that foster elder well-being (GCA, 2020). NbS also encompasses implementing green roofs, permeable pavements, urban forests, and water-retention parks to naturally mitigate both the UHI effect and flash flooding. Benjakitti Forest Park is the example of NbS. It features wetlands that form a low maintenance ecosystem. It supports storm water retention, cleaning, and biodiversity. The boardwalks bring people to connect with nature (Tan, 2025).

Co-Design and Design Thinking: Sustainable urban intervention must escape top-down mandates. Using "Design Thinking" methodologies allows elder communities to articulate their requirements without the constriction of external authorities, creating tailored solutions that safeguard local cultural identity and enhance community capital (Gozzoli et al., 2022).

Involving equity-centered design, it transitions away from technocratic, top-down engineering solutions toward inclusive governance. This involves co-designing community spaces with elderly populations to ensure green infrastructure doubles as accessible, climate-safe, and socially vibrant public domains (Somsopon et al., 2022).

Social & Intergenerational Infrastructure: Regenerative models require active community asset building. Participatory Action Research (PAR) models deployed within Thailand demonstrate that converting public infrastructure (e.g., older adult schools) into integrated community hubs can act as anchors for cognitive stimulation, intergenerational storytelling, and caregiver support networks (Jitdorn et al., 2026; APTU, 2026).

2.4 Urban Aging and Socio-Spatial Vulnerabilities

Thailand is experiencing one of the fastest demographic transitions in Southeast Asia, with projections indicating it will become a super-aged society by 2050. It means over 35% of its population will be aged 60 or older. The capital city's rapid urbanization has outpaced elderly-friendly infrastructure (Somsopon et al., 2022). Scholars identify several critical systemic gaps:

The Built Environment: Traditional urban neighborhoods in Bangkok often lack accessibility, universal design, and safe public transport options, driving social isolation (Somsopon et al., 2022).

Socio-Economic Strains: A significant portion of urban elders face financial precarity, lack substantial retirement income, and have limited digital literacy, which hinders their capacity to access modern community facilities or emergency alerts (Somsopon et al., 2022; Sawangnate et al., 2022).

3 The Resilience, Regeneration, and Age-Friendly Cities

The concept of urban resilience has evolved significantly over the past two decades. Early formulations emphasized engineering resilience—a system's capacity to return to equilibrium following disturbance. Contemporary frameworks, however, recognize socio-ecological resilience

as encompassing adaptation, transformation, and learning. For aging populations, resilience carries distinct dimensions: physical resilience (mobility and health maintenance), psychological resilience (cognitive and emotional adaptation), and social resilience (community support networks and continued participation).

Regenerative urbanism extends resilience thinking by shifting from bouncing back to "bouncing forward". This actively restores and enhances ecological and social systems rather than merely maintaining existing conditions. Regenerative approaches put attention to nature-based solutions (NbS), circular resource flows, and human-nature reciprocity. In the context of aging, regenerative cities would not only protect older adults from climate hazards but actively engage them as stewards of green-blue infrastructure, leveraging their knowledge, time, and place-attachment as community assets rather than viewing aging solely as a service burden.

The World Health Organization's Age-Friendly Cities framework, launched in 2007, has become the dominant paradigm for urban aging policy. Its eight domains—outdoor spaces and buildings; transportation; housing; social participation; respect and social inclusion; civic participation and employment; communication and information; and community support and health services—provide a comprehensive blueprint (Durongdej & Amornsiriphong, 2025). However, critics note three limitations. First, the framework assumes resource availability that middle-income cities lack. Second, it inadequately addresses climate-environmental dimensions of urban aging. Third, its implementation has been predominantly assessed in high-income contexts, creating what scholars call a resource-implementation gap.

3.1 Thailand's Demographic Transition and Bangkok's Aging Landscape

Thailand's aging trajectory is extraordinary. The proportion of older adults (aged 60+) increased from 10% in 2005 to 20% in 2022—a doubling in just 17 years. By 2033, projections indicate 28% of Thais will be elderly. This compressed transition carries profound implications. Unlike developed nations that industrialized before aging, Thailand's economic development remains incomplete, limiting fiscal capacity for age-friendly infrastructure.

Nationally, over 15 million Thais are aged 60 and above, representing more than 20% of the population. Among these, 5.26 million (37.2%) continue working primarily due to income necessity rather than choice. Nearly half of Thailand's older adults have insufficient income, with 31.6% earning between 83-167 Baht (US$2.53-5.08) daily, and 19.9% earning less than 83 Baht daily. Approximately 66.7% have no savings whatsoever. These economic vulnerabilities are magnified in Bangkok, where living costs significantly exceed rural areas.

Bangkok's older adult population exhibits distinctive characteristics. Official 2025 registration data shows 5,469,328 residents, though the functional population (including unregistered migrants) likely exceeds 14 million. Age-sex disaggregation reveals 211,862 women

aged 60-64 in 2025, reflecting the female predominance in older cohorts (CEIC, 2026). This feminization of aging carries implications for housing, income security, and social support systems.

3.2 Climate Hazards and Older Adult Vulnerability in Bangkok

Bangkok's environmental vulnerabilities are well-documented. The city floods annually during monsoon season, with climate change intensifying rainfall extremes. Sea-level rise threatens long-term inundation of low-lying districts. Additionally, extreme heat has emerged as a critical health threat: in 2026, BMA activated 304 cooling centers as heat indices reached dangerous levels.

Emerging research demonstrates that flooding's health impacts extend beyond immediate physical risks. A 2025 study examining Thailand's Resilient City Policy found that flooding significantly affects cognitive health among middle-aged and older adults, with multi-component resilience interventions showing promise in mitigating these effects. The mechanisms linking flooding to cognitive decline likely involve chronic stress, social disruption, and reduced healthcare access during flood events.

Nature-based solutions have gained traction as climate adaptation strategies in Bangkok. Research on informal settlements reveals that older adults—particularly women—play central roles as stewards of community gardens and canal revegetation projects. These stewardship activities provide multiple benefits: psychological resilience, social bonding, and ecological function. However, the same study identified barriers to sustained stewardship, including invisible environmental care labor (unrecognized work disproportionately performed by older women), disbenefits of nature (allergies, pests, physical strain), and fragmented governance across multiple agencies.

3.3 Age-Friendly Infrastructure Developments in Bangkok

Recent BMA initiatives signal growing commitment to age-inclusive urban development. The Green Bridge revitalization, scheduled for completion in mid-2026, transforms a 1.6-kilometer pedestrian corridor connecting Lumpini and Benchakitti Parks. Notably, the project incorporates Universal Design principles, including elevators and specialized ramps for elderly and disabled users. Additional features include impact-reducing surfaces for safe running and cycling, comprehensive CCTV coverage, and integration with "15-Minute Parks" and "Planting a Million Trees" initiatives.

The ACTIVATE Bangkok project, implemented by ICLEI (2025) and UN-Habitat, promotes climate-resilient transit-oriented development (TOD) with explicit attention to elderly inclusivity. The project's three adaptation dimensions—infrastructure, urban environment, and social behavior—recognize that mobility systems must accommodate older adults' diverse needs. Meanwhile, public-private partnerships have launched Day Care Service models providing comprehensive daytime care, health screenings, and rehabilitation activities for Bangkok's elderly.

These initiatives align with BMA's vision of becoming a Health Capital. This is a metropolis ensuring equitable healthcare access.

3.4 Empirical Age-Friendly City Research in Bangkok

Two recent empirical studies provide crucial baseline data for understanding Bangkok's age-friendly city status. A mixed-methods study of 1,000 older adults and 195 multi-sectoral stakeholders identified significant service disparities across WHO domains. Importance-Performance Analysis revealed an average gap of 1.34 (on a 5-point scale), with Communication and Information (2.03 gap), Housing (1.93), and Outdoor Spaces (1.78) identified as highest-priority areas. The study proposed a Resource-Constrained Age-Friendly City (RC-AFC) framework grounded in three principles: Priority Hierarchy Adaptation (systematic resource allocation to highest-gap domains), Multi-Sectoral Resource Optimization (collaboration as structural necessity), and Leapfrog Innovation Potential (constraint-driven solutions bypassing traditional resource-intensive pathways).

A complementary study examining elderly quality of life across six Bangkok pilot districts found overall quality of life rated "high" (mean = 4.21), with environmental and psychological dimensions scoring highest. However, limitations persisted in income adequacy, sleep quality, and social engagement. According to WHO criteria, five districts rated "very good" while Suan Luang District rated only "good." Key weaknesses included housing conditions and economic participation opportunities. The proposed model integrates WHO domains with Active Aging and Universal Design principles, emphasizing five strategic directions: elderly-friendly public transportation, safe and accessible housing, expanded social and economic participation, inclusive communication systems, and local partnerships.

This study develops the Bangkok Resilient and Regenerative Cities for Elders (BRRCE) framework. It integrates: (1) climate-resilient infrastructure adapted to older adult needs, (2) age-inclusive regenerative systems engaging elders as environmental stewards, (3) resource-optimization mechanisms for fiscal-constrained implementation, and (4) multi-sectoral governance structures enabling coordinated action.

4 Method

4.1 Research Design

This study employs a convergent parallel mixed-methods design, integrating quantitative assessment of older adult needs and service gaps with qualitative exploration of multi-sectoral collaboration mechanisms and lived experiences of climate hazards. This design is appropriate for the research questions, as it enables both generalizable gap identification and in-depth understanding of contextual factors shaping resilience and regeneration.

4.2 Study Setting

Bangkok, Thailand's capital and largest metropolitan area, serves as the study setting. The city comprises 50 districts with diverse socio-economic and environmental characteristics. Six

districts were purposively selected to capture variation in: (1) flood risk (high: Bang Khun Thian, low: Pathum Wan), (2) heat vulnerability (based on green space coverage and building density), (3) elderly population density, and (4) existing age-friendly infrastructure. Selected districts include: Bang Khun Thian (coastal, flood-prone), Suan Luang (identified as needing improvement in prior research), Phra Nakhon (historic core with high tourist foot traffic), Ratchathewi (dense residential-commercial mix), Bang Kapi (established residential area), and Pathum Wan (high-access to parks and healthcare).

4.3 Quantitative Component

Sampling and Participants. A stratified random sample of 500 older adults (aged 60+) was recruited from six districts. Stratification ensured representation across age groups (60-69, 70-79, 80+), gender, and living arrangements (alone, with spouse, with children, in multigenerational households). Inclusion criteria required residence in the district for at least one year and cognitive ability to provide informed consent.

Measures. The survey instrument comprised six validated scales and demographic items:

(1) WHO Age-Friendly City Domain Satisfaction: 32 items across eight domains, rated on 5-point Likert scales (1=very dissatisfied to 5=very satisfied). Cronbach's α in pilot testing ranged from 0.82 to 0.91 all domains.

(2) Climate Hazard Exposure and Impact: 12 items assessing flood experience (past 3 years), heat-related illness symptoms, evacuation needs, and assistance required.

(3) Resilience Capacity: The Brief Resilience Scale (6 items, α=0.87) measuring ability to bounce back from stress.

(4) Social Participation and Loneliness: The UCLA 3-item Loneliness Scale (α=0.89) and participation frequency in community activities.

(5) Physical and Mental Health: Self-rated health (single item), the Patient Health Questionnaire-2 (PHQ-2) for depression screening (α=0.83), and activities of daily living (ADL) limitations.

(6) Environmental Stewardship Engagement: Four items assessing participation in community gardening, canal clean-up, tree planting, or other NbS activities.

Procedure: Surveys were administered face-to-face by trained enumerators (community volunteers) during January 2026. Enumerators completed 3 hours of training including ethics, survey administration, and cultural competency. A social online group (Line group) was set up for cooperation and answer further questions. Surveys were conducted in Thai, with average completion time of 30 minutes.

Analysis: Quantitative data were analyzed using SPSS Version 29. Descriptive statistics (means, standard deviations, frequencies) characterized the sample. Importance-Performance Analysis (IPA) mapped domain importance against satisfaction ratings. One-way ANOVA compared district differences. Multiple regression identified predictors of resilience capacity and health outcomes.

4.4 Qualitative Component

From survey respondents, 48 older adults (8 per district) were purposively selected for in-depth interviews, ensuring diversity in age, gender, living arrangement, and climate hazard exposure. Additionally, 24 key informants were recruited: 6 BMA officials (from Social Development, Environment, and Transport departments), 6 private sector representatives (property developers, healthcare providers), 6 civil society organization leaders (age-focused NGOs, community-based organizations), and 6 academic experts (urban planning, gerontology, climate adaptation).

Semi-structured interview guides were developed separately for older adults and key informants. Older adult interviews explored: (1) daily mobility and access to services, (2) experiences of flooding and heat, (3) social connections and participation, (4) involvement in environmental stewardship, and (5) suggestions for city improvement. Key informant interviews addressed: (1) current age-friendly and resilience initiatives, (2) collaboration mechanisms and barriers, (3) resource allocation and prioritization strategies, (4) innovation examples, and (5) policy recommendations. Interviews lasted 45-90 minutes, were audio-recorded (with consent), and transcribed verbatim in Thai.

Photovoice Component: A photovoice substudy engaged 18 older adults (3 per district) in documenting their lived environments. Participants received digital cameras and attended a 2-hour orientation on photography ethics and storytelling. Over two weeks, participants photographed places, practices, and conditions relevant to aging, resilience, and regeneration. Subsequent individual interviews elicited narrative explanations of selected photographs.

Analysis: Thematic analysis followed Braun and Clarke's six-phase approach: familiarization, initial coding, theme generation, theme review, definition, and write-up. Coding was conducted in Thai; illustrative quotes were translated to English by a bilingual researcher and back-translated for accuracy. NVivo 14 supported data management and analysis. Inter-coder reliability (κ=0.84) was established on 20% of transcripts.

4.5 Integration and Synthesis

Quantitative and qualitative findings were integrated during interpretation using joint display analysis. Four integration points were identified: (1) priority gap identification (quantitative IPA results contextualized by qualitative accounts), (2) climate vulnerability mechanisms (statistical associations explained by narrative experiences), (3) stewardship patterns (participation rates illuminated by photovoice narratives), and (4) collaboration barriers (stakeholder perspectives framed by resource constraint data).

5 Results

5.1 Sample Characteristics

Of 500 targeted participants, 453 completed surveys (90.6% response rate). Non-response primarily resulted from health issues, relocation, and refusal. The sample comprised 62% female

(n=281) and 38% male (n=172). Age distribution: 60-69 years (52.4%), 70-79 (31.8%), 80+ (15.8%). Living arrangements: with spouse only (34.2%), with adult children (41.5%), alone (15.6%), multigenerational (6.1%), other (2.6%). Educational attainment: no formal education (18.3%), primary (51.7%), secondary (19.4%), tertiary (10.6%). Monthly personal income: none (22.1%), less than 5,000 Baht (34.6%), 5,000-9,999 Baht (25.4%), 10,000-19,999 Baht (12.3%), 20,000+ Baht (5.6%). Reflecting national patterns , 66.8% reported no savings.

District-level comparisons revealed significant socio-economic variation. Suan Luang and Ratchathewi had higher proportions living alone (21.3% and 19.8%, respectively) than Bang Khun Thian (9.5%). Bang Khun Thian showed highest poverty rates (41.2% with income <5,000 Baht/month) and lowest tertiary education (4.3%).

5.2 Age-Friendly City Domain Satisfaction and Gaps

Table 1 presents domain satisfaction means, importance ratings, and gap scores (importance minus satisfaction).

Table 1: Importance-Performance Analysis of WHO Age-Friendly Domains (N=453).

Domain	Satisfaction Mean (SD)	Importance Mean (SD)	Gap Score	Priority Ranking
Community Support & Health Services	3.42 (0.89)	4.78 (0.52)	1.36	4
Transportation	3.28 (0.94)	4.81 (0.48)	1.53	3
Housing	2.95 (1.01)	4.75 (0.56)	1.80	2
Outdoor Spaces & Buildings	3.05 (0.96)	4.79 (0.51)	1.74	2
Social Participation	3.38 (0.88)	4.65 (0.61)	1.27	5
Respect & Social Inclusion	3.56 (0.85)	4.59 (0.64)	1.03	6
Civic Participation & Employment	2.64 (1.12)	4.42 (0.78)	1.78	2
Communication & Information	2.87 (1.08)	4.83 (0.47)	1.96	1

Note: 5-point Likert scales (1=very dissatisfied/low importance; 5=very satisfied/high importance). Gaps calculated as Importance minus Satisfaction, with higher positive gaps indicating greater priority need.

Communication and Information emerged as the highest-priority gap (1.96), consistent with prior Bangkok research identifying this domain as most problematic. Qualitative interviews revealed multiple dimensions of this gap.

Housing (1.80 gap) and Outdoor Spaces and Buildings (1.74) also ranked as high priority. Specific housing concerns included affordability (74% of renters reported spending >40% of income on housing), accessibility modifications (91% of homes lacked grab bars or ramps), and flood vulnerability (68% of ground-floor dwellings experienced inundation in past three years). Civic Participation and Employment (1.78 gap) reflected both limited opportunities and age discrimination:

District comparisons revealed significant variation ($F(5,1077)=8.43$, $p<.001$, $\eta^2=0.038$). Bang Khun Thian reported lowest overall satisfaction (M=2.89, SD=0.67), while Pathum Wan reported highest (M=3.67, SD=0.58). Suan Luang—previously identified as a "good" rather than "very good" district —showed particular weakness in housing (M=2.71) and outdoor spaces (M=2.84).

5.3 Climate Hazard Exposure and Health Impacts

Flood exposure was widespread: 57.3% of participants reported household flooding in the past three years, with 22.6% experiencing flooding severe enough to require evacuation or relocation. Bang Khun Thian (89.5% flooded) and Bang Kapi (68.0%) were most affected; Pathum Wan (12.5%) least affected.

Extreme heat exposure was even more universal: 94.2% reported experiencing heat-related discomfort in summer months, with 31.7% meeting criteria for heat illness (dizziness, nausea, or heat exhaustion) in the past year. Heat vulnerability was significantly associated with housing type: residents of traditional wooden houses (common in older Bangkok districts) reported more severe heat impacts (M=3.87 on 5-point severity scale) than those in modern apartments (M=2.94) or condominiums (M=2.63), $F(2,1080)=41.62$, $p<.001$.

Multivariate regression (Table 2) examined predictors of self-rated health and cognitive complaints, controlling for age, gender, income, and pre-existing conditions.

Table 2: Regression Models for Health Outcomes

Predictor	Self-Rated Health (β)	Cognitive Complaints (β)
Age (years)	.214***	.187***
Female	-.052	.076*
Monthly Income (log)	.187***	-.145***
Flood Severity (0-3)	-.128***	.201***
Heat Illness (past year)	-.176***	.094**
Social Participation (frequency)	|.163***	-.112**
Cooling Center Access	.092**	-.058
Green Space Access (minutes walking)	.112**	-.067*
R^2	.287	.224

Note: N=453. Standardized beta coefficients reported. *p<.05, **p<.01, ***p<.001.

Both flood severity and heat illness significantly predicted worse self-rated health and increased cognitive complaints, consistent with prior research linking flooding to cognitive health among Thai older adults. Notably, social participation and green space access showed protective effects, while cooling center access was associated with better self-rated health.

Qualitative interviews illuminated mechanisms underlying these associations. A 72-year-old woman in Suan Luang described the cognitive burden of flood preparedness:

Heat vulnerability intersected with economic constraints. Many older adults reported limiting cooling center use due to mobility barriers or dignity concerns:

5.4 Environmental Stewardship and Regenerative Practices

Despite challenges, 28.7% of older adults reported active engagement in environmental stewardship activities: community gardening (16.4%), canal clean-up (12.7%), tree planting (8.9%), or other NbS actions (5.2%). Participation was significantly higher among women (32.7% vs. 21.4% men, χ^2=15.83, p<.001) and those with stronger social networks (OR=2.34 for high vs. low participation, 95% CI: 1.67-3.28).

Photovoice participants (Figure 1) documented rich stewardship practices often invisible to formal planning. However, stewardship participation faced barriers.

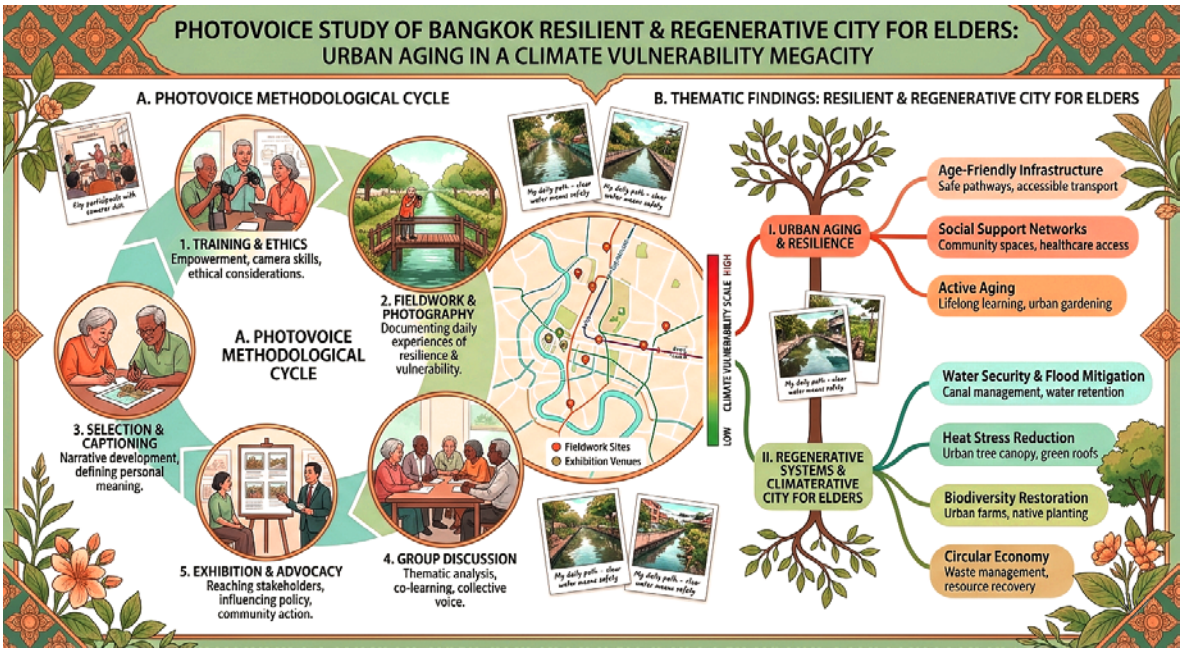

Figure 1: Photovoice used in this study with the findings.

Governance fragmentation emerged as a critical constraint. Multiple agencies—BMA Department of Environment, District Offices, Public Health Centers, Metropolitan Electricity Authority—have overlapping but uncoordinated responsibilities for green-blue infrastructure. Key informants acknowledged the problem:

5.5 Multi-Sectoral Collaboration: Barriers and Innovations

Key informant interviews revealed significant collaboration barriers. Resource constraints were paramount: municipal budgets for older adult services typically allocate only 2-5% of total spending, and most BMA departments lack dedicated aging portfolio. The Social Development Department (SDD) has responsibility for elders, but has no budget for infrastructure. The Environment Department has budget for parks but no mandate for age-friendly design. The Transport Department builds sidewalks but they do not consult SDD about where elders actually walk. Everyone does their part, but nobody connects the parts.

Despite barriers, innovative practices emerged. One district office developed a "budget co-management" pilot, pooling allocations from three departments (social, environment, transport) with community-led oversight. Another initiative matched older adult stewards with school environmental education programs, addressing intergenerational knowledge transfer while

providing nominal stipends. Academic partners documented these innovations as "leapfrog potential"—constraint-driven solutions bypassing traditional resource-intensive pathways.

5.6 Summarized Results

The highest-priority service gaps were Communication and Information (gap=1.96/5), Housing (1.80), and Outdoor Spaces (1.74). Flood exposure in the past three years affected 57.3% of participants; 94.2% experienced heat-related discomfort. Regression models showed flood severity (β=-0.128, $p<0.001$) and heat illness (β=-0.176, $p<0.001$) independently predicted worse self-rated health and increased cognitive complaints. Despite challenges, 28.7% of older adults actively engaged in environmental stewardship (community gardening, canal clean-up, tree planting), though this labor remained invisible in municipal planning. Qualitative findings revealed fragmented governance, budget constraints (2-5% municipal allocation for elder services), and power asymmetries in multi-sectoral collaboration, alongside innovative practices including budget co-management and intergenerational programming.

6 Discussion

This mixed-methods investigation of Bangkok Resilient and Regenerative Cities for Elders yielded four principal findings. First, age-friendly service gaps persist across WHO domains, with Communication and Information, Housing, and Outdoor Spaces identified as highest priority—consistent with prior Bangkok research but extending those findings by quantifying climate vulnerability intersections. Second, flooding and extreme heat exposure significantly predict worse health outcomes among older adults, with cognitive health particularly affected. Third, older adults actively engage in environmental stewardship, contributing to regenerative urban systems despite invisible labor and governance fragmentation. Fourth, multi-sectoral collaboration remains structurally constrained but shows innovation potential through budget co-management and intergenerational programming.

6.1 Toward an Integrated Resilience-Regeneration-Age-Friendly Framework

These findings suggest limitations in applying the WHO Age-Friendly Cities framework uncritically in climate-vulnerable, resource-constrained contexts. Bangkok's reality—compressed aging, fiscal limitation, climate hazard convergence—requires theoretical integration not adequately addressed by existing frameworks.

Resilience for older adults is not merely about infrastructure robustness but about what we term "adaptive capacity bundles". It is the combination of physical accessibility (elevators, ramps, cooling centers), information accessibility (early warnings in appropriate formats), and social accessibility (networks providing assistance during shocks). Our regression models showed that social participation and green space access independently predicted better health outcomes, suggesting that social-ecological resilience operates through multiple reinforcing channels.

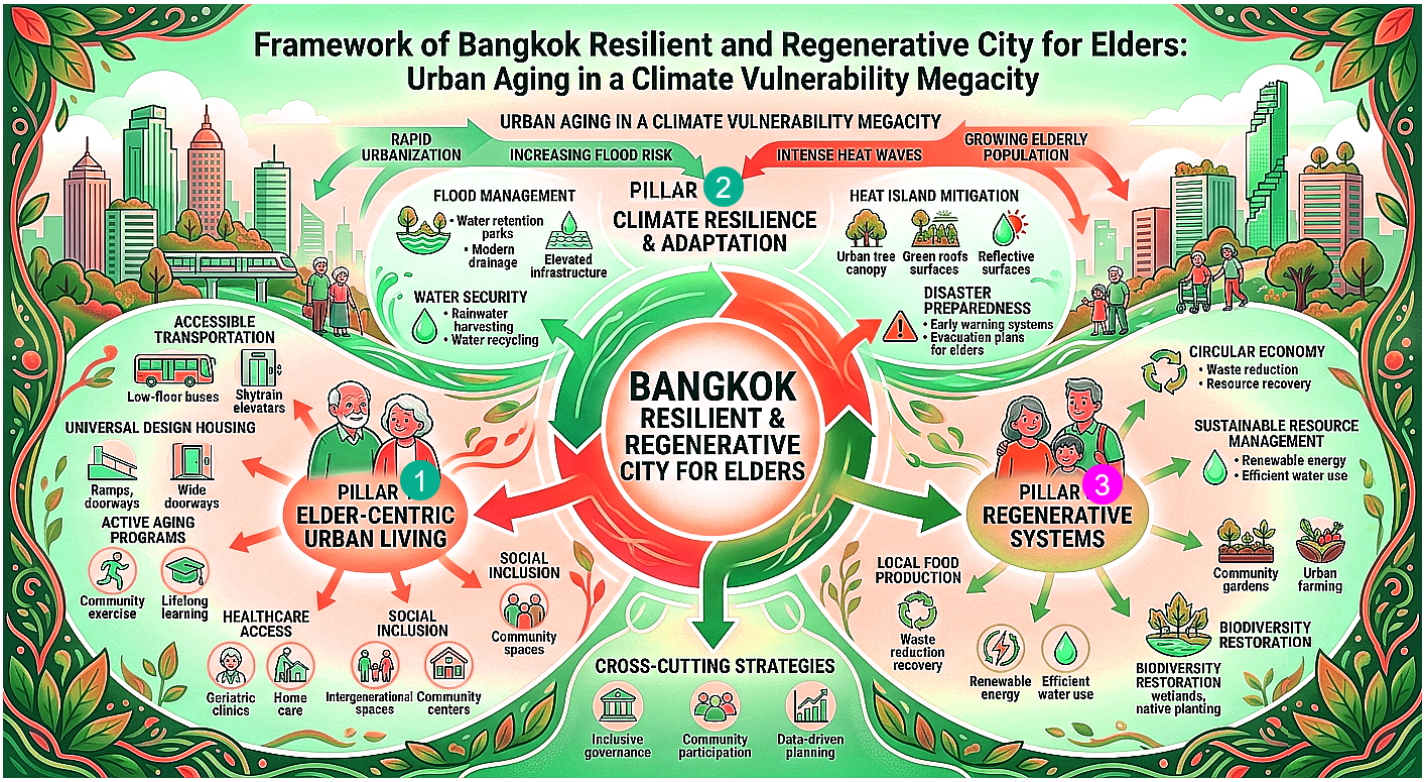

Figure 2: Framework of Bangkok Resilient and Regenerative City for Elders (BRRCE): Urban Aging in a Climate Vulnerability Megacity.

Figure 2 shows a conceptual framework designed for a Resilient and Regenerative City for Elders in Bangkok. It visualizes a holistic approach in three main pillars. This framework integrates these pillars with cross-cutting strategies for data-driven planning and community participation. All are set within the unique context of Bangkok's urban landscape.

Pillar 1: Elder-Centric Urban Living: Focusing on accessible transportation, universal design housing, and social inclusion to create a supportive environment for the aging population.

Pillar 2: Climate Resilience & Adaptation: Addressing the specific challenges of a climate-vulnerable megacity, including flood management, heat island mitigation, and disaster preparedness.

Pillar 3: Regenerative Systems: Promoting sustainability through a circular economy, renewable resources, and biodiversity restoration to ensure long-term urban health.

Regenerative urbanism's emphasis on human-nature reciprocity finds empirical grounding in older adults' stewardship practices. The 28.7% participation rate—likely an underestimate given invisible labor—demonstrates that older adults are not passive resilience recipients but active ecosystem contributors. However, our findings also reveal that regenerative potential remains systematically undervalued. The concept of "invisible environmental care labor" accurately captures how stewardship work by older women sustains green-blue infrastructure without recognition in municipal budgets, planning documents, or performance metrics.

The Resource-Constrained Age-Friendly City (RC-AFC) framework requires explicit climate integration. The original RC-AFC principles—Priority Hierarchy Adaptation, Multi-Sectoral Resource Optimization, Leapfrog Innovation Potential—adequately address resource constraints

but treat climate as exogenous rather than constitutive. We propose extending RC-AFC to RC-AFC+ (Resilience-Climate-Age-Friendly) by adding a fourth principle: Climate-Grounded Prioritization, whereby domain gaps are weighted by climate vulnerability exposure. In Bang Khun Thian, for example, Housing gap (1.80 overall) effectively exceeds Communication gap (1.96 overall) when flood exposure is factored into importance weighting.

6.2 Policy and Practice Implications

Integrated Green-Gray Infrastructure. Current age-friendly infrastructure developments—Green Bridge, cooling centers, TOD projects—represent important steps. However, our findings indicate that these remain fragmented rather than integrated. We recommend establishing Resilience Corridors. These are continuous accessible pathways linking cooling centers, parks, healthcare facilities, and transit hubs within 400-meter walking distance (adjusted for slower walking speeds). The Green Bridge provides a model, but coverage remains limited.

Communication Justice. The Communication and Information gap (1.96) demands multi-channel approaches recognizing technological heterogeneity. While digital platforms expand, 34% of Bangkok's older adults lack smartphone access or digital literacy. Resilient communication requires redundant systems: voice announcements, community volunteer networks, visible signage, and household-level notifications for high-risk individuals.

Stewardship Recognition and Compensation. The invisible labor of older environmental stewards should be recognized through formal mechanisms: "stewardship micro-grants" (500-1,000 Baht/month), municipal acknowledgment in planning documents, and integration of elder knowledge into NbS design. Regenerative cities cannot be built by disregarding those who already regenerate.

Budget Co-Management Pilots. The budget co-management innovation observed in one district deserves systematic evaluation and scaling. By pooling allocations across departments and including community oversight, resource fragmentation can be partially overcome. This aligns with Multi-Sectoral Resource Optimization principles while addressing power asymmetries in collaboration.

7 Conclusion

Bangkok stands at the intersection of two epochal transformations: the transition to an aged society occurring within a single generation, and climate change intensifying chronic and acute environmental hazards. This research demonstrates that these transformations cannot be addressed separately. The older adults of Bangkok are not merely vulnerable populations requiring protection but active agents of resilience and regeneration—maintaining community gardens, cleaning canals, supporting neighbors, and sustaining urban ecological functions despite fragmented governance and invisible labor.

The Bangkok Resilient and Regenerative Cities for Elders framework, this study grounds in empirical evidence from older adults and in-depth interviews. It offers an integrated approach. It

recognizes that Communication and Information gaps exacerbate flood vulnerability. It acknowledges that Housing inadequacy compounds heat illness risk. It documents how older women's stewardship sustains green-blue infrastructure without municipal recognition. And it identifies concrete pathways—resilience corridors, communication justice, stewardship compensation, budget co-management—toward more age-inclusive, climate-resilient, ecologically regenerative urban futures.

As Thailand approaches super-aged status by 2033, and as climate hazards intensify, the question is not whether Bangkok can afford to invest in resilient and regenerative infrastructure for elders. The question is whether the city can afford not to—recognizing that those who have sustained families, communities, and ecosystems across decades remain essential assets for navigating the uncertain decades ahead.

8 Availability of Data and Materials

All information is included in this article.

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