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RESEARCH ARTICLE

Does aging-friendly enhance sustainability? Evidence from Hong Kong

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Abstract

The aging population is one of the demographic changes in the 21st century. World Health Organization defines an age-friendly city as a place that has an “inclusive and accessible urban environment that promotes active aging.” It receives considerable attention in the field of gerontology and contains important aspects of sustainable urban development. Unfortunately, there have not much research that addresses the relationship between aging-friendly and sustainability. There is a need to modify the market mechanism to achieve environmental objectives while striking a balance between social and economic considerations. This paper aims to empirically examine the integrated relationships between the dense urban environment and the social and emotional needs of the elderly in the Hong Kong context. The on-street survey was conducted in eight districts in Hong Kong to collect the opinions about aging-friendly criteria and sustainability indicators. It utilizes principal component analysis and multiple regression technique to unveil the mask of their intrinsic relationship. The empirical results suggest how the aging-friendly factors have impacted the economic, environmental, and social sustainability to a certain extent. Notably, two key findings were revealed from the empirical results. (a) “Outdoor Spaces” is consistently found not to be a planning factor that can enhance three types of sustainability, irrespective of the age groups in Hong Kong; (b) “Community Support and Health Services” is regarded as a significant factor, with the exception of economic sustainability (age group ≤ 60).

KEYWORDS

aging-friendly, economic sustainability, environmental sustainability, Hong Kong, principal component analysis, social sustainability

1 | INTRODUCTION

Due to the declining birth rate and better medical care, the average life expectancy is longer, and the world is aging unavoidably (World Health Organization [WHO], 2016; Roser, 2017). In Hong Kong, for example, population aged 65 or above is anticipated to rise from 12.5% in 2010 to 31.6% by 2050 (Census and Statistics Department, 2015). The proportion of Japanese people aged 65 or above will increase from 23% in 2010 to 36% by 2050 (Shitoh, 2012). Although the aging problems are very severe in Asian countries, the western

counterparts also witness the similar phenomenon. For example, in the United States and the United Kingdom, the figures are expected to be 21% and 24% respectively by 2050 (Shitoh, 2012).

Because the population becomes aging, public facilities and housing characteristics should be modified to meet their changing need. Previous studies demonstrate that the environment has a significant impact on people's quality of life, especially in their later life (Oswald & Kasper, 2012). Notwithstanding the different degree of physical and functional limitations, elderly still prefer living independently in their residence rather than in health care center. Another aspect of

aging-friendly is the accessibility factor. In designing public facilities for the elderly, Carlisle and Stankovich (2014) consider accessibility as one crucial factor. Accessibility involves location, barrier-free, wayfinding, and circulation that directly affect the elderly's access to the facilities. Availability of public transport is also an essential factor that affects the accessibility to public facilities by the elderly. If the public bus or mass transit railway stations are far away from their apartments, elderly will limit their use of public facilities.

Aging in place and the provision of open space permit the elderly to remain independent, retain autonomy, and stay connected to lines of social support (Yung, Ho, & Chan, 2017). Previous studies also suggest that open space can provide the elderly with a place for the enjoyment of different activities and enhancing social interaction, social ties, and creates a sense of community and place attachment (NSW Government, 2010). Particularly, Orsega-Smith, Payne, Mowen, Ho, and Godbey (2007) point out that spending time with friends and families and participating in recreational physical activities are essential for elderly to achieve healthy aging (see also Sasidharan, Payne, Orsega-Smith, & Godbey, 2007; Yung et al., 2017). Social activities are proven to reduce the risk of mortality, disability, and depression and improve cognitive health, as suggested by many medical studies (Smith & Christakis, 2008). Oswald and Wahl (2004) suggest that elderly aging in place is influenced by factors, such as personal health, income, neighborhood social cohesion, and the environment. It can be achieved by maintaining health while having the social connection and access to public services in daily life.

In highly urbanized cities, such as Hong Kong, taller and denser residential buildings have been built to satisfy the housing need of the growing population. Undoubtedly, open space will be compromised for the build-up of new developments, which results in a loss of social network, local culture, and identity accordingly. The lower class people in Hong Kong face many challenges in their later stage of life, such as unaffordable accommodation and medical treatment. Many elderly have to reside in old urban districts because of low housing rents and familiar neighborhood. It is common to see local elderly usually spend most of the day in public parks due to limited living space in Hong Kong. Although the Hong Kong SAR Government offers medical and social assistance to the residents below the poverty line, it has never bridged the gap between the elderly and the built environment (Kwok, 2013).

When society has become aging, aging in place urges the possibilities in modifying the existing facilities to fit the need of the elderly. However, Hong Kong Housing Authority gives no permission to the residents of public rental housing to alter the layout of public rental housing units freely to cater to the changing need of the elderly. There is a pressing need to investigate and improve the urban environment to enhance healthy aging and aging in place in Hong Kong.

This paper aims to examine the integrated relationships between the dense urban environment and the social and emotional needs of the elderly in the Hong Kong context. How to include the aging-friendly features into the sustainable planning by altering the design of housing estate and public space? How to encourage the private developers to participate in developing sustainable public housing for the elderly (to-be) to achieve their business and the economy as a whole? This paper is organized as follows. Section 2 presents the

literature review related to the background of aging and living environment in Hong Kong, aging-friendly city indicators, and sustainability index. Section 3 describes the way we conduct surveys and the principal component analysis (PCA) and multiple regression model we utilize to achieve our objective. Section 4 presents the estimated results, diagnostic statistic, together with our discussions. Section 5 summarizes the main findings.

2 | LITERATURE REVIEW

2.1 | Aging and living environment in Hong Kong

Due to mild weather, economic progress, and stable political environment, Hong Kong was ranked 43 in the list of the most livable city in the world, based on the Global Liveability Ranking (ejinsight, 2016). Despite low tax rates imposed, most local people have not had pension fund until December 2000, except civil servants and university academic staffs employed before July 1997. Starting from December 2000, all employees in Hong Kong have to contribute 5% of their income (or a cap of HK\$1,000) to their mandatory provident fund accounts on a monthly basis, administered by commercial banks and regulated by the Hong Kong Mandatory Provident Fund Schemes Authority (MPFA, 2018). Employers are also required to contribute another 5% of its employees' monthly income to their accounts. More recently, the cap is raised to HK\$1,500.

The implementation of mandatory provident fund schemes is very late in Hong Kong, when compared with many western countries. Unlike other Asian countries, such as China, Japan, and South Korea, there are no national health insurance schemes implemented in Hong Kong on the other hand. Hence, it is prevalent that local young residents join at least one private health insurance plans whereas unaffluent people and elderly usually rely on medical treatment offered by public hospitals and clinics at low cost. To cater for unaffluent residents, Hong Kong still provides limited medical and social assistance for them to access their medical need (Department of Health, 2015). The Hong Kong Hospital Authority is an independent body, which provides medical treatment and rehabilitation services to patients through specialist clinics and outreaching services and hospitals. There are also polyclinics or specialist clinics that provide specialist clinic sessions in a supplement to general outpatient services in the more densely populated areas. For patients with financial difficulties, there is a well-established mechanism for applying a fee waiver (Department of Health, 2015).

There also exist several assistance schemes that provide a safety net for those who cannot meet their basic needs (Social Welfare Department, 2016). For example, the Comprehensive Social Security Assistance Scheme is designed to complement residents' income up to a level that can meet their basic needs. To be eligible for obtaining the assistance, an applicant must satisfy the residence requirements and pass the financial tests including income test and asset test. For the former, the total assessable income of an applicant or the household must not exceed the income limit set by the scheme. For the latter, a physically healthy person cannot have an asset over HK\$31,500, and the limit is raised to HK\$47,500 for a physically healthy person

with dependents or a disabled or medically ill person. In the case of a household, the upper bound is raised to HK\$84,000.

¹ Other assistance schemes include Criminal and Law Enforcement Injuries Compensation Scheme, Traffic Accident Victims Assistance Scheme, and Emergency Relief. Despite these assistance schemes, the allowances given to the recipients are still not sufficient to help the poor make ends meet.

2.2 | World Health Organization's aging-friendly guideline for the Hong Kong context

A checklist that composed of 88 core age-friendly features was developed by the World Health Organization (WHO) to guide cities in becoming age-friendly in each of the domain. This checklist was considered by WHO (2007, pp. 10–11) as a “faithful summary” of the views expressed by older persons themselves and is “a tool of a city's self-assessment and a map to chart progress.” Table 1 summarizes the key areas of physical and social environments for creating an age-friendly environment for Hong Kong, based on WHO's age-friendly city guideline (2007). These seven key areas are developed from the original eight key areas of age-friendly guidelines by WHO (2007). The subset of design criteria are derived from the WHO (2007) guidelines, the existing literature, and experts' opinions (interview done by the authors). The list has been altered and adapted into the Hong Kong context, and the definitions of the response and explanatory variables are the core of the survey and analysis of this article.

2.3 | Economic, social, and environmental sustainability

The concept of sustainable development has first emerged since the 1960s when environmentalists have a hot debate on the relationship between economic growth and the natural environment (Daly, 1974, 1992). Although most literature suggest that there are three types of sustainability, namely, economic, environmental, and social sustainability (Basiago, 1999), sustainable city planning is a relatively new concept at the municipal level that is designated to achieve a balanced economic, environmental, and socio-cultural growth through active citizen participation approaches (Sustainable Cities International, 2012). These three dimensions of sustainability must be considered in creating sustainable communities (American Planning Association, 2000). To achieve sustainable development, there has been a general belief that society must harmonize economic growth, social inclusion, and environmental protection. These three elements are interrelated and essential for all members of society. Table 2 summarizes the generic sustainable planning criteria based on the literature review.

Economic sustainability refers to the use of various strategies for employing existing resources optimally to create economic value in such a way that long-term economic growth can be achieved. It implies a production system that meets present consumption levels without compromising future needs (Basiago, 1999). Khan (1995) points out that economic sustainability encompasses notions of growth, development, and productivity. Hence, a fair market system, sustainable economic growth, and use of resources are interrelated.

Efficient public transportation networks, diversified businesses, highly adaptable and efficient use of land, and the availability of employment also contribute to a sustainable economy (Lee & Chan, 2008).

Environmental sustainability requires maintaining natural resources as economic inputs and outputs simultaneously, which includes eco-system integrity, carrying capacity, and biodiversity (see Basiago, 1999; Khan, 1995). As an example, the conservation of existing properties includes the value of building redevelopment and cultural heritage preservation (Lee & Chan, 2008). Well-located and properly designed open spaces with greenery and vegetation are value-added to urban areas. The public transport system is also vital to environmental sustainability. The availability and accessibility of open spaces, public facilities, and provisions for the vulnerable groups are tied up with transit-oriented development.

Social sustainability is established on the concept that a decision or policy should enhance the betterment of society (Wanamaker, 2016). Khan (1995) states that social sustainability deals with the relations among equity, empowerment, accessibility, participation, sharing, cultural identity, and institutional stability. Particularly, awareness, participation, acceptance, institutional requirements, and responsibility are considered as essential criteria by Balkema, Preisig, Otterpohl, and Lambert (2002). Other studies, such as Lee and Chan (2008), consider quality welfare planning and provisions as the most critical factor affecting social sustainability, which focuses mostly on meeting psychological and emotional needs of the public. Their findings also suggest that pollution-free living and accessibility both matter in affecting social sustainability.

2.4 | Indicator measurement approach

To measure aging-friendly and sustainability, the use of indicators has been very popular since the publication of WHO (2007, 2015) and United Nations Economic Commission for Europe (UNECE, 2013; UNECE, 2014). In complement to the works by international organizations, there are a number of scholars and organizations that advocate the use of indicators in or laying down guidelines on measuring these two abstract concepts, respectively (Bell & Morse, 2003, 2008; Council on Aging of Ottawa, 2017). The use of indicators has also been prevalent in many research fields, such as science (Krogh, 1937), social science (Philibert, Frossard, & Maslowski, 1982), economics (Williams & Siddique, 2007), and policy analysis (Pintér, Swanson, & Barr, 2006).

Generally speaking, an indicator can either be a quantitative or qualitative measure that is derived from a series of factual observations, and it can reveal relative positions in a specific area. When evaluated at regular intervals, an indicator can specify the direction and magnitude of change over a specific period (Ciegis & Ramanauskiene, 2009). Hence, indicators contain quantitative information by nature, which help describe how specific phenomena change over time. Economic, social, and environmental indicators are commonly used to report on the situation about human, natural, and natural and human-made systems (Sacramento River Watershed Program, 2010). Notwithstanding the vast volume of literature about aging-friendly and sustainability, there has been no detailed study that utilizes a quantitative approach to investigate their interlocked relations. This

TABLE 1 WHO's adapted seven key areas for the aging-friendly city of Hong Kong

Age-friendly city design criteria	Literature
1. Outdoor Spaces (OS)	
• Universal accessibility	WHO (2007) and Age-Friendly Portland Advisory Council (2013)
• Appropriate public facilities	WHO (2007)
• Quality green environment	WHO (2007) and Global City Indicators (2013)
• Safe and secure public spaces	WHO (2007), Van Vliet (2009), and UNECE (2014)
• Special customer services	WHO (2007) and Global City Indicators (2013)
• Management and maintenance	Turel, Yigit, and Altug (2007)
2. Transportation (TRANSPORT)	
• Affordability	WHO (2007) and Van Vliet (2009)
• Public transport frequency and reliability	WHO (2007); Prasad, Steels, Dagg, and Kano (2013); and Chaterjee and DeVol (2012)
• Travel connectivity to destinations	WHO (2007) and Chaterjee and DeVol (2012)
• Proximity to the bus stops on foot	WHO (2007), Prasad et al. (2013), and Chaterjee and DeVol (2012)
• Universal access in public transportations: wheelchair users & cyclist friendly	WHO (2007), Prasad et al. (2013), and European Innovation Partnership on Active and Healthy Ageing (2014)
• Pedestrian and bus stop signage	WHO (2007)
• Age-friendly features	WHO (2007)
• Safety for transportation facilities	WHO (2007) and UNECE (2014)
3. Buildings and Neighborhood (BN)	
• Housing options	WHO (2007), Prasad et al. (2013), and Chaterjee and DeVol (2012)
• Affordability of Housing	WHO (2007) and Chaterjee and DeVol (2012)
• Universal access	Phillipson (2012) and Age-Friendly Portland Advisory Council (2013)
• Safe and comfortable facilities	Chaterjee and DeVol (2012) and UNECE (2014)
• Fresh clean air in the buildings/rooms/neighborhood	Interviews with Expert 4 and Expert 18
• Signage (sufficient, legible/voice activation)	Interviews with Expert 2, Expert 4, and Expert 8
• Enough housing for younger people in the district	Elderly Commission (2009)
• Management and maintenance	Interviews with Expert 2 and Expert 12
4. Social/Civic Participation and Employment (SPE)	
• Affordability, choices, and accessibility of events	WHO (2007), Prasad et al. (2013), and Age-Friendly Portland Advisory Council (2013)
• Lifelong learning programs for elderly	WHO (2007), Van Vliet (2009), Prasad et al. (2013), and Medical Research Council (2010)
• Addressing isolation and intergenerational programs	WHO (2007), Van Vliet (2009), and Age-Friendly Portland Advisory Council (2013)
• Recognition of the elderly contribution	WHO (2007) and Age-Friendly Portland Advisory Council (2013)
4. Social/Civic Participation and Employment (SPE)	
• Podium for socializing near to marketplaces	UNECE (2014) and Interview with Expert 2
• Working and volunteering opportunities after retirement	WHO (2007), Medical Research Council (2010), and EuroHealthNet (2012)
• Elderly participation in community planning and political leadership	WHO (2007), European Innovation Partnership on Active and Healthy Ageing (2014), Age-Friendly Portland Advisory Council (2013), and UNECE (2014)
• Addressing discrimination in the workplace	Medical Research Council (2010), and Interviews with Expert 2 and Expert 5
• Age-friendly and progressive public policy	European Innovation Partnership on Active and Healthy Ageing (2014) and Interviews with Expert 5 and Expert 6
5. Respect (RESPECT)	
• Lifelong learning programs:	WHO (2007) and City of Melbourne (2006)
• Computer classes	Interview with Expert 5
• History/cultural heritage	Interview with Expert 13
• Socializing skills/personal empowerment	Interviews with Expert 7 and Expert 10
• Fashion/beauty/styling	Interview with Expert 5
• Personal health care including elderly friendly exercises/sports	Chaterjee and DeVol (2012)
6. Communication and Information (CI)	
• Printed material in legible size and format	WHO (2007) and Age-Friendly Portland Advisory Council (2013)
• Hear/understand service staff over the phone or in person	WHO (2007)

(Continues)

TABLE 1 (Continued)

Age-friendly city design criteria	Literature
<ul style="list-style-type: none"> • Technology aids and equipment 	WHO (2007), Prasad et al. (2013), UNECE (2014), and Global City Indicators (2013)
7. Community Support and Health Services (CHS)	
<ul style="list-style-type: none"> • Affordable public health care services 	WHO (2007), Van Vliet (2009), and Chatterjee and DeVol (2012)
<ul style="list-style-type: none"> • Accessibility and availability of public health care services 	WHO (2007), Van Vliet (2009), Prasad et al. (2013), EuroHealthNet (2012), Chatterjee and DeVol (2012), and UNECE (2014)
<ul style="list-style-type: none"> • Need for in-home assistance for independent living seniors 	WHO (2007)
<ul style="list-style-type: none"> • Promoting personal healthcare 	WHO (2007), Medical Research Council (2010), Chatterjee and DeVol (2012), and Global City Indicators (2013)
<ul style="list-style-type: none"> • Psychological needs for addressing the isolation issue 	Interviews with Expert 7 and Expert 16
<ul style="list-style-type: none"> • Image grooming is good to build up elderly self-esteem 	Van Vliet (2009)

Note. UNECE: United Nations Economic Commission for Europe; WHO: World Health Organization.

TABLE 2 Summary of generic sustainable planning criteria

Sustainable planning criteria	Literature
1. Economic Sustainability (ecos)	
<ul style="list-style-type: none"> • Economic growth and employment opportunities 	Hyde et al. (2007); Chan and Lee (2009); Shen, Ochoa, Shah, and Zhang (2011); Mega and Pedersen (1999); and Atkins (2013)
<ul style="list-style-type: none"> • Compact mixed-use development (residential/commercial/retail) 	UN Habitat (2013); American Planning Association (2000); and Jonathan Rose Companies LLC, Wallace Roberts and Todd (2009)
<ul style="list-style-type: none"> • High quality and efficient public transportation system/networks 	Calthrope Associates (2013) and Atkins (2013)
<ul style="list-style-type: none"> • Building positive city image (landmarks/visual impacts/landscape/people) 	Urban Land Institute (2012) and Home and Community Agency (2009)
<ul style="list-style-type: none"> • Appropriate use of resource: land & labor etc. 	Environment, Heritage, and Local Government (2009) and Atkins (2013)
<ul style="list-style-type: none"> • Promoting fair market system, financial & social equity at the workplace 	Blazer (2011)
<ul style="list-style-type: none"> • Diversity of economies 	Australian Sustainable Built Environment Council (2011), Shen et al. (2011), and Tang (2011)
2. Environmental Sustainability (envs)	
<ul style="list-style-type: none"> • Smart growth and green infrastructures 	American Planning Association (2000); Hyde et al. (2007); Welch, Benfield, and Raimi (2011); Chan and Lee (2009)
<ul style="list-style-type: none"> • Zero-waste management (greater adoption of renewable energy/resource/recycling) 	Hyde et al. (2007), Welch et al. (2011), and Sustainable Cities International (2012)
<ul style="list-style-type: none"> • Urban greeneries and vegetation 	Hyde et al. (2007), Welch et al. (2011), and Sustainable Cities International (2012)
<ul style="list-style-type: none"> • Transit-Oriented Development (TOD) 	American Planning Association (2000), Welch et al. (2011), and Australian Sustainable Built Environment Council (2011)
<ul style="list-style-type: none"> • Biodiversity (maritime/wetland/natural parks ...) 	Basiago (1999); Shen et al. (2011); Environment, Heritage, and Local Government (2009); and Atkins (2013)
<ul style="list-style-type: none"> • Cultural heritage/preservation 	Welch et al. (2011) and Hong Kong Planning Department (2002)
<ul style="list-style-type: none"> • Redevelopment of brownfield sites and reuse of existing buildings/sites for development 	Welch et al. (2011) and Chan and Lee (2009)
3. Social Sustainability (socs)	
<ul style="list-style-type: none"> • Community focus and community delivery (enhancing the sense of place) 	Chan and Lee (2009), Australian Sustainable Built Environment Council (2011), Atkins (2013), and Blazer (2011)
<ul style="list-style-type: none"> • Mixed housing types (for intergeneration and aging in place) 	UN Habitat (2013) and Goh (2006)
<ul style="list-style-type: none"> • Social mix in community (cultural/age/gender/income) to foster city liveability 	UN Habitat (2013); American Planning Association (2000); Blazer (2011); and Jonathan Rose Companies LLC, Wallace Roberts and Todd (2009)
<ul style="list-style-type: none"> • Efficient public transportation system (easy access to work & public facilities) 	American Planning Association (2000), Welch et al. (2011), Calthrope Associates (2013), Chan and Lee (2009), Sustainable Cities International (2012), and Mega and Pedersen (1999)
<ul style="list-style-type: none"> • Age-friendly features, universal design & barrier-free access 	Welch et al. (2011); Calthrope Associates (2013); Atkins (2013); Jonathan Rose Companies LLC, Wallace Roberts and Todd (2009)
<ul style="list-style-type: none"> • Low carbon communities living program 	American Planning Association (2000) and Low Carbon Hub (2014)
<ul style="list-style-type: none"> • Public participation in community building and public policy consultation 	Basiago (1999), Urban Land Institute (2012), Chan and Lee (2009), Mega and Pedersen (1999), Blazer (2011)

Source: Chan et al. (2015).

paper aims to explore whether an improvement in aging-friendly can enhance sustainability.

3 | METHODOLOGY

On the basis of a comprehensive literature review about the provision of elderly precincts and the needs of the elderly, our survey questionnaire comprises two parts: the age-friendly design criteria with its seven categories and the list of sustainable planning criteria related to economic, environmental, and social sustainability. The list of sustainable planning criteria is chosen based on the literature review about commonly used indicators relevant to sustainable neighborhood planning (Hong Kong Planning Department, 2002; Chan & Lee, 2009; American Planning Association, 2000; Blazer, 2011; UN Habitat, 2013; Australian Sustainable Built Environment Council, 2011). These indicators are reconciled to the sustainable planning considerations and practices of the selected best practice case studies to provide consistency.

Once the list of age-friendly design and sustainable planning criteria has been selected, we seek expert opinions by making interviews with 21 local experts. They are chosen for their expertise in the fields of urban design, architecture, urban planning, active aging, and public policy. These experts come from representatives from government and private organizations involved in planning and aging society, such as the Elderly Commission, Asia Pacific Institute of Ageing Studies, Hong Kong Housing Society, Elderly Service, Social Welfare Department, and the Institute of Active Ageing. Accommodating different views and feedbacks from the experts, this process of designing the questionnaires is to modify the existing WHO guidelines (WHO, 2007) in hopes of better fitting the Hong Kong situation. Moreover, the sustainable planning criteria are then

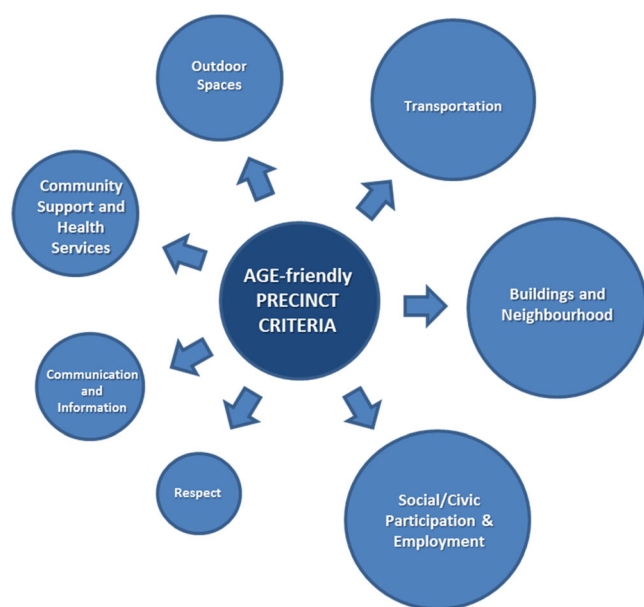


FIGURE 1 Age-friendly cities indicators for Hong Kong. Source: Chan, Qian, Lehmann, and Li (2015) [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Profile of the selected districts

Major elderly precincts in HK	Population ('000 persons) (2013)	Percentage of the population above 65 years old (2013)	Average household income (HK\$) ^a (2013)	Percentage of elderly with secondary education or above (2013)	Number of residential care homes (2013)	Number of park/garden (2012)	Existing and planned provision of open space (2008)	Gross area per capita for elderly (m ² per person) (2013)
Sha Tin	643	12.6	24,900	36.6	40	86	240.0	29.7
Fan Ling and Sheung Shui (North District)	303.2	11.0	21,400	26.4	58	137	119.9	35.9
Yau Tsim Mong (West Kowloon)	311.9	13.8	22,000	45.6	56	97	105.4	24.5
Sham Shui Po	382.1	16.3	17,900	33.6	79	58	119.2	19.2
Central and Western	250.1	13.1	34,300	51.8	47	116	57.1	17.5
Hung Hom (Kowloon City)	376.9	15.0	25,100	46.4	94	86	164.5	29.1
Kwun Tong	638.9	16.8	17,500	30.9	53	109	231.6	21.5

Source: Chan et al. (2015).

^aUnder the linked exchanged system, US\$1 is equivalent to HK\$7.8.

weighted according to its degree of importance and appropriateness to Hong Kong. In the Hong Kong context, the list differs slightly comparing with WHO's guideline regarding the segregation of the outdoor spaces and buildings and consider the urban context where buildings and neighborhood are combined as another area. The WHO Key Areas 4 and 6 were combined into social/civic participation and employment whereas respect is considered as one key area. Figure 1 presents the seven key areas of an age-friendly environment for Hong Kong. The bubble diagram indicates the relative importance of the seven key areas evaluated by the experts. Although transportation, buildings and neighborhood, and social/civic participation and employment are of top priority in creating an age-friendly precinct in Hong Kong, respect is considered to be least significant.

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A 5-point Likert scale ("1" = lowest importance, "2" = low importance, "3" = neutral, "4" = importance, "5" = highest importance) is used in the questionnaire. Our survey is then conducted among residents and pedestrians in eight selected districts of Hong Kong. They are Central District, Fan Ling, Hung Hom, Kwun Tong, Sham Shui Po, Sha Tin, Sheung Shui, and West Kowloon. These districts are chosen because they are the representative districts of Hong Kong in respect of the characteristics of population groups. A brief description of these eight districts is listed in Table 3.

3.1 | Quantitative analysis

After obtaining the opinions from the respondents, we use the PCA to transform this information into seven predictor variables and three response variables in the form of continuous data before proceeding to estimate the empirical estimation. The main purposes of a PCA are to analyze data in order to identify patterns and to reduce dimensions of the dataset with minimal loss of information (Pearson, 1901; Fisher & Mackenzie, 1923; Hotelling, 1933; Wold, 1966; Wold, Esbensen, & Geladi, 1987). It is a statistical tool for illustrating the covariance structure of a set of variable. Particularly, the method allows researchers to identify the principal directions in which the data vary (Turk & Pentland, 1991). In our questionnaire, we have 10 categories of questions, each of which has three to eight dimensions. These dimensions are then combined into one variable for each category of questions to construct predictor and response variables for carrying out quantitative analysis.

After constructing the response and predictor variables, we use a simple multiple regression model to estimate whether the predictor variables can exert an influence on the response variable. The response variables are economic sustainability, environmental sustainability, and social sustainability, respectively. In particular, our models are specified as follows:

$$ECOS = \alpha_1 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_7 x_7 + \varepsilon_1, \quad (1)$$

$$ENVS = \alpha_2 + \theta_1 x_1 + \theta_2 x_2 + \dots + \theta_7 x_7 + \varepsilon_2, \quad (2)$$

$$SOCS = \alpha_3 + \omega_1 x_1 + \omega_2 x_2 + \dots + \omega_7 x_7 + \varepsilon_3. \quad (3)$$

where ECOS is defined as the economic sustainability indicator. ENVS is defined as the environmental sustainability indicator. SOCS is defined as the social sustainability indicator. x_1, x_2, \dots, x_7 are defined as the seven aging-friendly indicators. $\beta_1, \beta_2, \dots, \beta_7, \theta_1, \theta_2, \dots, \theta_7, \omega_1, \omega_2, \dots, \omega_7$ are the estimated coefficients.

TABLE 4 Determinants of economic sustainability

Variables	Full sample	Age group ≤60	Age group 61–80+
α	0.00341 (0.08613)	0.06131 (1.59533)	−0.083319 (−1.33656)
Outdoor Spaces	0.01871 (0.41602)	0.01721 (0.32390)	0.02337 (0.339648)
Transportation	−0.00326 (−0.07054)	−0.01069 (−0.19548)	0.03858 (0.58372)
Building & Neighborhood	0.11593** (2.15948)	0.19236*** (3.29666)	−0.00586 (−0.06972)
Social/Civic Participation & Employment	0.20477*** (3.37393)	0.15285** (2.29610)	0.28520*** (3.08625)
Respect	0.08479** (2.00083)	0.06128 (1.20886)	0.11434 (1.58703)
Communication & Information	0.10008** (2.16719)	0.02170 (0.41237)	0.19107*** (2.87892)
Community & Health Services	0.21565*** (4.96201)	0.26420*** (4.60286)	0.15615** (2.36698)
R^2	0.31628	0.30993	0.36588
Adjusted R^2	0.31007	0.29956	0.35093
Log likelihood	−963.0492	−564.6508	−385.8770
F-statistic	50.95038	29.89915	24.48043
Prob (F-statistic)	0.00000	0.00000	0.00000
Durbin–Watson statistics	1.67004	1.68357	1.31098
Observation	779	474	305

Note. Figures in parentheses are z-statistics.

*Statistically significant at 10% level. **Statistically significant at 5% level. ***Statistically significant at 1% level.

4 | EMPIRICAL RESULTS AND DISCUSSIONS

A review of the results (full sample and two subsamples) for the three sustainability index is presented in this section. The estimated coefficients (along with the *t*-statistics), goodness-for-fit measures, and diagnostic tests are shown in Tables 4–6, and Table 7 presents a summary of our estimated results. Our discussions focus on two subsamples only: people aged ≤ 60 (younger population) and people aged 61+ (elderly). We first explain the relationship between seven aging-friendly factors and economic sustainability. For people aged 60 or below, those variables Outdoor Spaces, Transportation, Respect, and Communication & Information have been found not to explain a change in economic sustainability. It is quite normal that outdoor space,

transport, respect, and communications are not directly related to economic issues but social issues. The rest of the predictor variables, such as Building & Neighborhood, Social/Civic Participation & Employment, and Community & Health Services, are positively associated with the economic sustainability index because all these variables are economic factors that enhance the growth of gross domestic product. Conclusively, the predictor variables explain approximately 30% of the variations in the economic sustainability index (Table 4, column 2).

For the elderly, those variables Outdoor Spaces, Transportation, and Building & Neighborhood have been found not to explain a change in economic sustainability. Social/Civic Participation & Employment, Respect, Communication & Information, and Community & Health Services are positively associated with the economic

TABLE 5 Determinants of environmental sustainability

Variables	Full sample	Age group ≤ 60	Age group 61–80+
C	–0.00070 (–0.01961)	0.01925 (0.43128)	–0.01243 (–0.24500)
Outdoor Spaces	0.08167* (1.79964)	0.10502* (1.81589)	0.05072 (0.79999)
Transportation	0.07445* (1.82376)	0.09608* (1.78098)	0.04392 (0.60377)
Building & Neighborhood	0.071919 (1.60017)	0.08833 (1.58633)	0.04502 (0.61312)
Social/Civic Participation & Employment	0.06038 (1.36198)	0.04955 (0.84265)	0.07663 (1.17871)
Respect	0.14376*** (3.30680)	0.11257* (1.72453)	0.18265*** (2.91082)
Communication & Information	0.11972*** (2.91603)	0.09000* (1.69117)	0.16017*** (2.69954)
Community & Health Services	0.20441*** (4.23982)	0.24296*** (3.99215)	0.16078** (2.55560)
R^2	0.30577	0.31975	0.30000
Adjusted R^2	0.29944	0.30951	0.28339
Log likelihood	–965.2523	–579.9672	–381.6120
<i>F</i> -statistic	48.32230	31.22516	18.06088
Prob (<i>F</i> -statistic)	0.00000	0.00000	0.00000
Durbin–Watson statistics	1.86922	1.71899	1.97842
Observation	776	473	303

Note. Figures in parentheses are *z*-statistics.

*Statistically significant at 10% level. **Statistically significant at 5% level. ***Statistically significant at 1% level.

TABLE 6 Determinants of social sustainability

Variables	Full sample	Age group ≤ 60	Age group 61–80+
C	–0.00449 (–0.15467)	0.04227 (1.19525)	–0.06201 (–1.30607)
Outdoor Spaces	0.01795 (0.41735)	0.01877 (0.35567)	0.02647 (0.44509)
Transportation	0.13109*** (2.89872)	0.19545*** (3.77562)	0.04231 (0.61935)
Building & Neighborhood	0.06753 (1.34054)	0.06981 (1.08548)	0.06752 (0.98817)
Social/Civic Participation & Employment	0.15808*** (3.64879)	0.13137** (2.17256)	0.19749*** (3.25095)
Respect	0.09888*** (2.55037)	0.07905 (1.58711)	0.124825** (2.12471)
Communication & Information	0.13560*** (3.28579)	0.13558*** (2.71475)	0.12851** (2.30725)
Community & Health Services	0.27997*** (6.73954)	0.29117*** (5.08611)	0.26806*** (4.62586)
R^2	0.442510	0.47449	0.41694
Adjusted R^2	0.437435	0.46656	0.40320
Log likelihood	–881.4211	–508.585	–364.8263
<i>F</i> -statistic	87.19955	59.84906	30.34006
Prob (<i>F</i> -statistic)	0.00000	0.00000	0.00000
Durbin–Watson statistics	1.98638	2.01732	1.77475
Observation	777	472	305

Note. Figures in parentheses are *z*-statistics.

*Statistically significant at 10% level. **Statistically significant at 5% level. ***Statistically significant at 1% level.

TABLE 7 Summary of the results

Variables	Economic sustainability full sample	Economic sustainability age group ≤ 60	Economic sustainability age group 61–80+	Environmental sustainability full sample	Environmental sustainability age group ≤ 60	Environmental sustainability age group 61–80+	Social sustainability full sample	Social sustainability age group ≤ 60	Social sustainability age group 61–80+
Outdoor Spaces				+	+				
Transportation				+	+		+	+	
Building & Neighborhood	+								
Social/Civic Participation & Employment	+	+	+				+	+	+
Respect	+			+	+	+	+		+
Communication & Information	+		+	+	+	+	+	+	+
Community & Health Services	+	+	+	+	+	+	+	+	+

sustainability index. Conclusively, the predictor variables explain approximately 35% of the variations in the economic sustainability index (Table 4, column 3).

Turning to environmental sustainability, the younger population does not consider Building & Neighborhood and Social/Civic Participation & Employment as a factor to explain a change in environmental sustainability. The rest of the predictor variables, such as Outdoor Spaces, Transportation, Respect, Communication & Information, and Community & Health Services, are positively associated with the environmental sustainability index. Conclusively, the predictor variables explain approximately 31% of the variations in the environmental sustainability index (Table 5, column 2).

For the elderly, those variables Outdoor Spaces, Transportation, Building & Neighborhood, and Social/Civic Participation & Employment do not explain a change in environmental sustainability. The rest of the predictor variables, such as Respect, Communication & Information, and Community & Health Services, are positively associated with the environmental sustainability index. Conclusively, the predictor variables explain approximately 28% of the variations in the environmental sustainability index (Table 5, column 3).

Finally, the younger population does not consider Outdoor Spaces, Building & Neighborhood, and Respect as a factor to explain a change in social sustainability. These have been attributed to the fact that people living in public housing come from mainly lower class, and they focus only on what they consider as basic needs, such as food and accommodation. Under low tax rate and low welfare system, many people only focus on “shelter,” and they will not expect too much from the government as long as they can live in public rental housing at low costs. To these people, outdoor space, neighborhood, and respect are such a luxury.

The rest of the predictor variables, such as Transportation, Social/Civic Participation & Employment, Communication & Information, and Community & Health Services, are positively associated with the social sustainability index. It is quite natural because all these variables are related to communication among people. Conclusively, the predictor variables explain approximately 47% of the variations in the social sustainability index (Table 6, column 2).

For the elderly, those variables Outdoor Spaces, Transportation, and Building & Neighborhood, do not explain a change in social sustainability. Concerning open space and neighborhood, local elderly may perceive these things as beyond their concern and do not pay much attention to these improvements. They will be delighted if they can live in public rental housing at low costs. Under better welfare system, elderly of western countries are protected by the government in many aspects, and they are eager to participate in the community in order to create a living environment at which they can stay at their home for the rest of their life. Under different welfare systems, parts of the “basic needs” of the elderly in western countries are considered as a luxury by local elderly.

In Hong Kong, public transport is very convenient and affordable. Some public bus and mass transit railway companies even offer concessionary prices to people aged 65+. Combining the situation is that many local elderly usually avoid from having unnecessary trips in order to save money. Hence, it is quite natural that transportation is not a factor that contributes to explain variations in social sustainability.

The rest of the predictor variables, such as Social/Civic Participation & Employment, Respect, Communication & Information, and Community & Health Services, are positively associated with the social sustainability index. It is quite natural because all these variables are related to communication among people. Conclusively, the predictor variables explain approximately 40% of the variations in the social sustainability index (Table 6, column 3).

5 | CONCLUSIONS

The article explores the relationships between the two global challenges: aging-friendly and sustainability. How to possibly incorporate these two into the initiatives and planning guidelines? Hong Kong is selected as a case study city because its unique combination of severity in aging challenge and the urban density as a test ground for sustainable planning. The objective of this study are first to identify the key planning and design criteria for aging-friendly and three types of sustainability, and then to explore the relationship between them. Questionnaire surveys are conducted in eight selected districts of Hong Kong. This paper employs the PCA to construct seven underlying factors for the planning of aging-friendly and three response variables of economic, environmental, and social sustainability, based on existing literature and experts' opinions. After constructing the response and explanatory variables, this paper estimates a multiple regression model for each type of sustainability to see whether these factors contribute to its variations.

Two key findings were revealed from the empirical results. It shows that "Outdoor Spaces" is consistently found not to be a planning factor that can enhance three types of sustainability, irrespective of the age groups; "Community Support and Health Services" is regarded as a significant factor in all equations, with the exception of economic sustainability (age group ≤ 60). In order to enhance sustainability, Hong Kong government is suggested to take initiative to create conditions that enable the private sectors to make the fullest possible contribution towards promoting housing and community support and medical care to the elderly.

The paper revisited an in-depth review on literature about age-friendly city guidelines initiated by WHO. The theoretical framework is generic and can be of good value for other countries/cities for similar study. The sustainability theory has been also explored in terms of economics, social, and environment. It is a good theoretical basis for city planning. Although this paper is a Hong Kong case study, the quantitative techniques adopted to make use of interviewees' opinions can be easily replicated to utilize survey data from other countries. This paper is a modest contribution to the literature on the use of PCA and multiple regression model frequently used by social scientists. In this paper, we have demonstrated the usefulness of interviewees' opinions and an econometric technique by which survey data can be scientifically examined.

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ENDNOTE

- ¹ For detailed description of the CSSA, please see Social Welfare Department (2018).

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