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How affordable housing becomes more sustainable? A stakeholder study

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ABSTRACT

Rapid urbanization poses a significant challenge of accommodating the poor, particularly in developing countries such as China where affordable housing has only been initiated a few years ago and will continue to be developed in the coming years. Two major considerations in affordable housing programs are cost and time, as the ability to meet the needs of low-income households is the main target of these programs. However, it is not a common strategy to address affordable housing shortage by means of incorporating sustainability features. One of critical issues is the lack of sustainability framework to integrate sustainability in affordable housing. This paper aims to identify the key sustainability performance indicators (KSPIs) which are useful to guide the development of affordable housing. A preliminary list of 42 key sustainability performance indicators of affordable housing was identified through an extensive literature review. This was followed by a questionnaire survey to solicit the professional views from three stakeholder groups, namely government, developers and academics in the Chinese construction industry. Via the fuzzy set theory and variance analysis, 24 KSPIs were finally highlighted. These findings provide useful references for policy makers as well as industry practitioners to develop affordable housing programs in a sustainable manner. This helps to achieve the sustainable development at the regional scale.

1. Introduction

The world's urban population is expected to grow from 3.6 billion in 2011 to 6.3 billion in 2050, while 94% of the increase will occur in developing countries (UN, 2012). It is estimated that 828 million people from developing countries live in slums and substandard housing while the number will rise to 1.4 billion by 2020 (Al-Saadi and Abdou, 2016; Desai, 2012; Govender et al., 2011). Consequently, accommodating the poor poses a significant challenge to developing countries during the urbanization process. To address this issue, affordable housing has become the agenda of many governments in a bid to improve the living condition of low-income households (Lin et al., 2015). Affordable housing usually refers to housing that is affordable to specified eligible households whose income is not adequate for them to access appropriate housing in the market (Winston and Montserrat, 2007).

The main target of affordable housing programs is to improve the housing affordability, especially for low-income households, based on government initiatives (Azevedo et al., 2010). Although many affordable housing programs have been initiated, there is a debate on whether the housing affordability of low-income households has been improved. For example, living in affordable housing might increase the spending on health care, energy bill, transportation and so on (Fuhry and Wells, 2013; Govender et al., 2011; Isalou et al., 2014). Charoenkit and Kumar (2014) argued the increment of spending on non-housing issues has deteriorated housing affordability. This leads to low demand and abandonment, causing a huge waste of public resources (Mulliner et al., 2013).

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Therefore, many studies attempted to address non-economic issues associated with affordable housing. For example, according to Mulliner et al. (2013), economic viability is not the only means to improve housing affordability. Rather, other sustainability issues should also be taken into consideration such as housing design, neighborhood environment, location, transportation routes, and work opportunities (Isalou et al., 2014). MacKillop (2013) argued sustainability is a basis of housing affordability by less spending on energy bills, transportation and health care (see also Roufechaei et al., 2014). Strong sense of belongings can also be created by better provision of public facilities and amenities (Chiu, 2003). Therefore, it is imperative to incorporate sustainability into affordable housing so that the housing affordability can be eventually improved.

Sustainability is generally elaborated as a development that satisfies the needs of the current generation not on the cost of compromising future generations (Golubchikov and Badyina, 2012; Lin et al., 2015). In this study, the sustainability can be defined as the development of affordable housing as to meet the housing needs of present medium-low income groups should not compromise the ability to meet the housing needs of their future groups (Li et al., 2016). The aims are striving for integral quality in terms of environmental, social and economic performances (Roufechaei et al., 2014). However, the sustainability issues are often overlooked when addressing the housing shortage, especially in developing countries (Ross et al., 2010). Economic sustainability has attracted much attention of affordable housing programs (Pullen et al., 2009; Winston and Montserrat, 2007). Environmental sustainability is not necessarily consistent with housing affordability which is commonly evaluated on a cost basis. This is because the capital cost of providing affordable housing will likely increase due to consideration of environmental sustainability (Pullen et al., 2010). The misconception leads to the rare adoption of sustainability as a way of achieving affordability (Golubchikov and Badyina, 2012; Nubi and Afe, 2014).

However, unlike market-oriented development, affordable housing, as a long term public investment, is not driven by the need for a quick return on investment and should include sustainability considerations (Fuhry and Wells, 2013). Although the initial cost may be slight higher, the life cycle cost and performance may be improved. For example, Coimbra and Almeida (2013) suggested that by incorporating sustainable construction into affordable housing programs, the cost is only increased by 4.2%. By contrast, a variety of life cycle benefits, such as reduced maintenance cost and reduced energy bills, can be expected. In addition, affordable housing programs have the ability to attract and retain the needed human resources for essential services (Gurstein, 2012). Therefore, it is imperative to integrate sustainability into housing planning and construction in affordable housing programs (Golubchikov and Badyina, 2012).

Sustainability performance of affordable housing in China presents a significant challenge to both government and industry as China is reported to experience the largest scale urbanization in human history. From 2010 to 2015, 36 million units of affordable housing will be constructed. Despite great efforts by governments to ensure the economic success of affordable housing programs, very little attention has been paid on the sustainability of affordable housing. Recent studies have focused on the sustainability in affordable housing programs, e.g. Pullen et al. (2010) and Azevedo et al. (2010). However, this may not be useful for Mainland China which is reported to experience the largest scale urbanization in human history. The paper therefore aims to: (1) evaluate the criticality of various sustainability performance indicators; and (2) develop a framework to support the integration of sustainability in affordable housing programs. This research was undertaken from perspectives of various stakeholders in affordable housing developments such as: governmental agencies, developers and academics. These parties involved in the decision making process or were providing supports in affording housing programs in China. Future studies will focus on other key stakeholders such as residents.

2. Affordable housing and sustainability

2.1. Affordable housing policy in China

China has been implementing housing reform programs in the housing industry during the last two decades (Zhang et al., 2013). However, since 1998, the skyrocketing housing prices in combination with insufficient provision of affordable housing have triggered widespread social complaints, threatening the socioeconomic and political stability (Chen et al., 2013). Housing policy has been shifted towards prompting the affordable housing construction in order to address the housing problems of vulnerable groups. Currently, the affordable housing programs in China, designed to target low-to-medium households, include Cheap Rent Housing (CRH), Public Rental Housing (PRH), Economic Comfortable Housing (ECH), Capped-Price Housing (CPH) and Shantytown Renovation Housing (SRH). CRH and PRH are designed mainly for renting to eligible households. By contrast, ECH, CPH and SRH are sold at below-market price to households with low-to- medium income. The PRH, as the only affordable housing program access to migrants, has become the mainstream of affordable program in the National Twelfth Five-year Plan (Chen et al., 2014). Meanwhile, it has been considered as an important measure to improve the affordable housing systems and deal with housing difficulties of the sandwich layer group (Li et al., 2016).

During the urbanization process in China, environment protection is considered as one of the core principles according to the *National New-type Urbanization Plan* (2014–2020) issued by Chinese central government in 2014 (SC, 2014). According to the G*reen Building Action Plan* released by the MHURD and the National Development and Reform Commission (Hereafter NDRC) in 2013, green building should account for 70% of newly built affordable housings by 2020 (NDRC and MOHURD, 2012). Meanwhile, the MHURD also released the *Technical guidelines of green affordable housing* which set up green building related criteria to be integrated in affordable housing since 2014 (SCGO, 2013).

The triple bottom line is a common approach of implementing sustainability. All the three pillars of sustainability, i.e. economic, social and environmental sustainability, should be taken into consideration. Nubi and Afe (2014) argued that defining housing affordability should also include social and environmental perspectives in addition to the widely accepted economic perspective. However, in the context of affordable housing, very few studies considered the three pillars of sustainability as a whole. In addition, although useful experience can be drawn from other countries, there is a need for China to develop its own framework to integrate sustainability in affordable housing given its large population and building density.

2.2. Economic sustainability

The main objective of affordable housing programs is to enhance housing affordability of low-income households. Integrating economic sustainability requires a consideration of both initial acquisition cost and future transportation cost and energy bill (Fuhry and Wells, 2013; Isalou et al., 2014). By reducing transportation cost and energy bill, low-income householders are allowed to spend more of their limited income on non-housing needs (Golubchikov and

Badyina, 2012; Ibem and Azuh, 2011). This can create more employment opportunities and provide more readily available people for employment at the same time (Muazu and Oktay, 2011). In addition, desirability of affordable housing programs (which refers to how the programs meet and exceed consumers' expectations) is also an important economic sustainability indicator, according to Pullen et al. (2009). Affordable housing programs should also consider the economic sustainability of developers (e.g. the cost effectiveness of the projects) to ensure that these programs can be developed on a continuous basis. While developers can adopt cost reduction strategies (such as the use of regionally available materials and techniques), providing stable financial incentives is needed for developers to secure financial viability (Pullen et al., 2009).

2.3. Environmental sustainability

In general, the environmental sustainability highlights the issues of climate change and mitigation of greenhouse gas emission. This macro objectives can be achieved by adopting various green technologies, sustainable materials as well as renewable energy and resources. This highlights the environmental sustainability indicators such as energy efficiency, water efficiency, effective utilizing resources, reliability and durability, efficient waste management, comfortable and healthy indoor environment, and reduction of footprint to minimize the biodiversity loss (Fuhry and Wells, 2013; Ross et al., 2010). As for low-income households, environmental sustainability can be important because their budget is limited and negative impact on their physical and mental health are unlikely to be improved without financial support (Winston and Montserrat, 2007). In addition, special attentions should be paid on the disaster resistance of affordable housing in developing countries which are more vulnerable to natural disasters (Charoenkit and Kumar, 2014). This requires appropriate land use planning to avoid settlement in risky areas. Similarly, mixed land using is strongly suggested for affordable housing as it increases the ability of accessibility, reduces transportation cost and helps to achieve efficient land use (Isalou et al., 2014; Turcotte and Geiser, 2010). Providing adaptability and flexibility in affordable housing is one of the strategies in sustainable affordable housing (Turcotte and Geiser, 2010). Adaptability satisfies the changing needs of residents as well as avoiding problems such as environment disruption and more resource consumption (Pullen et al., 2009). According to Ross et al. (2010), accessing to green public space is one of the key issues of a healthy and comfortable living environment with many beneficial effect on health and well-being which is often neglected in affordable housing programs (Dempsey et al., 2012).

2.4. Social sustainability

Social sustainability in affordable housing programs emphasizes the equitable distribution and consumption of housing resources with special attentions on horizontal equity and vertical equity (Chiu, 2003). While vertical equity refers to unequal treatment of people in unequal positions, horizontal equity is represented by equal treatment of people in equal positions. In addition, there should not be restrictions imposed on the distribution process and allowed all eligible residents of affordable housing to participate (Pullen et al., 2009). The second social sustainability performance can be measured by the increasing demand of sustainable housing. It is can be achieved by the increasing awareness of the benefits of living in sustainable buildings as well as the support from public policies (Myerson, 2007). As public funded project, affordable housing programs are excellent opportunities to demonstrate the benefits of living and building in a sustainable way (Gan et al., 2015). The third social sustainability performance is related to the housing quality and neighborhood environment (Chiu, 2003).

Affordable housing programs should fulfill the users' requirements (Ibem and Azuh, 2011). Local culture and aesthetic values should also be integrated in housing designing (Muazu and Oktay, 2011). For example, Pullen et al. (2009) suggested that affordable housing programs, especially in the area of dwelling sizes, should be accepted by surrounding communities as well as local governments. Provision diversified housing types can facilitate interaction and improve social relationships within the community (Winston and Montserrat, 2007). Community participation has been emphasized in affordable housing programs as it not only effectively improves social relationship but also satisfies the residents' needs of the current and the future (Ross et al., 2010). Attention should also be paid to the security of tenure as well as effective maintenance and management of properties, which is important for creating a sense of belonging and community stability (Azevedo et al., 2010). Meanwhile, Turcotte and Geiser (2010) emphasized the importance of addressing health and safety issues of workers during the maintenance and management of building as well as providing a fair compensation.

3. Research methodology

A hybrid research method was adopted in this research in order to identify key indicators for the sustainability performance of affordable housing developments. A comprehensive literature review was conducted to draw a preliminary list of sustainability performance indicators of affordable housing developments. This was followed by a questionnaire survey to investigate the criticality of these sustainability performance indicators from key stakeholders' point of view.

3.1. Study area and data collection

The questionnaire survey was conducted in the city of Chongqing, one of the municipal cities in China. In 2015, the GDP growth rate of Chongqing was 11%, 4.1% higher than the national average (Gan et al., 2016). During the 12th five year period, about 3 million newly added urban permanent residents were rural to urban migrant workers and this number is expected to reach 10 million by 2021. A large number of affordable housing programs are currently undertaken in Chongqing in order to accommodate the surging demand. Nearly 40 million square meters of PRH, about 67 thousand units, were constructed since 2011. Comparing with other cities, Chongqing had established the largest-scale PRH programs. This may motivate other local governments in terms of PRH provision. This is mainly attributed to a series of factors relating to political conditions, unusual incentives, land provision and so on (Zhou and Ronald, 2016).

The target population for this study was governmental agencies, developers and academics who were involved in the decision making process or were providing supports in affording housing programs in Chongqing. Future research opportunities exist to investigate preferences of residents and compare with results of this study. From May 2015 to July 2015, a total of 500 questionnaires were disseminated by e-mail or post and 102 valid responses were collected with a response rate of 20.4%. These responses are government agencies (29), developers (32), and academics (41). A total of 42 sustainability performance indicators (SPIs) in affordable housing programs were identified from literature review (Table 1). Respondents were asked to evaluate the criticality of the 42 SPIs via a 5-point Likert Scale (1 = extremely unimportant; 2 = unimportant; 3 = neutral; 4 = important; and 5 = extremely important).

Table 1
A list of performance indicators for the sustainability performance of affordable housing programs.

NO.	Sustainability performance indicators	References
Economic sustainability		
SPI1	Financial viability	(Chiu, 2003; Turcotte and Geiser, 2010)
SPI2	Cost effectiveness	(Isalou et al., 2014)
SPI3	Desirability	(Pullen et al., 2010)
SPI4	Affordable price/renting	(Winston and Montserrat, 2007)
SPI5	Reduced life cycle cost	(Roufechaei et al., 2014)
SPI6	Provide human resource for economic development	(Muazu and Oktay, 2011)
SPI7	Ensure balanced housing market	(Golubchikov and Badyina, 2012)
SPI8	Generate job opportunities	(Chiu, 2003)
SPI9	Reduced transportation cost	(Isalou et al., 2014)
SPI10	Cost recovery	(Isalou et al., 2014)
SPI11	Other non-housing related costs	(Ibem and Azuh, 2011)
SPI12	Reduced energy bills	(Fuhry and Wells, 2013)
SPI13	Integrate related industries of sustainable housing	(Fuhry and Wells, 2013; Ross et al., 2010)
Environmental sustainability		
SP14	Disaster resistance	(Azevedo et al., 2010; Charoenkit and Kumar, 2014)
SPI15	Land use efficiency	(Charoenkit and Kumar, 2014; Winston and Montserrat, 2007)
SPI16	High housing density	(Charoenkit and Kumar, 2014; Dempsey et al., 2012)
SPI17	Mixed land using	(Dempsey et al., 2012; Winston and Montserrat, 2007)
SPI18	Energy efficiency	(Ross et al., 2010; Roufechaei et al., 2014)
SPI19	Water efficiency	(Ross et al., 2010; Roufechaei et al., 2014)
SPI20	Adequate living spaces within small size unit	(Pullen et al., 2009; Winston and Montserrat, 2007)
SPI21	Comfortable and healthy indoor environment	(Chiu, 2003; Winston and Montserrat, 2007)
SPI22	Available green public spaces	(Ross et al., 2010; Winston and Montserrat, 2007)
SPI23	Effective waste management	(Chiu, 2003; Ross et al., 2010)
SPI24	Adaptability and flexibility	(Pullen et al., 2009; Turcotte and Geiser, 2010)
SPI25	Reliability and durability	(Fuhry and Wells, 2013)
SPI26	Effectively utilizing resources	(Ross et al., 2010; Roufechaei et al., 2014)
SPI27	Reduced footprint	(Nissinen et al., 2015; Ross et al., 2010)
SPI28	Minimize biodiversity loss	(Pullen et al., 2009; Tsai and Chang, 2012)
Social sustainability		
SPI29	Accessibility	(Dempsey et al., 2012; Isalou et al., 2014)
SPI30	Equability and fairness of housing distribution	(Chiu, 2003)
SPI31	Cultural and heritage conservation	(Chiu, 2003; Muazu and Oktay, 2011)
SPI32	Community participation	(Ross et al., 2010)
SPI33	Sense of community	(Chiu, 2003; Dempsey et al., 2012)
SPI34	Effective maintenance and management of properties	(Azevedo et al., 2010; Charoenkit and Kumar, 2014)
SPI35	Tenure security	(Azevedo et al., 2010; Winston and Montserrat, 2007)
SPI36	Minimize social segregation	(Chiu, 2003; Ross et al., 2010)
SPI37	Maximize the wellbeing of workers	(Turcotte and Geiser, 2010)
SPI38	Diversified housing types	(Winston and Montserrat, 2007)
SPI39	Social acceptability	(Chiu, 2003; Pullen et al., 2009)
SPI40	Suitability	(Ibem and Aduwo, 2013)
SPI41	Harmonious social relationships	(Chiu, 2003; Mulliner et al., 2013)
SPI42	Increased consciousness of environment protection	(Myerson, 2007)

3.2. Data analysis

3.2.1. Nonparametric test

The means and standard deviations of the SPIs were adopted to evaluate the criticality of the SPIs. The Kolmogorov–Smirnov test showed that the data did not follow a normal distribution. Therefore, nonparametric tests were adopted in this study, including Kruskal-Wallis test and Mann-Whitney *U* test (Ibrahim et al., 2016; Shao et al., 2017). The null hypothesis of Kruskal-Wallis test was that there was no significant difference between the mean ratings of different groups. If the p value was lower than 0.05, the null hypothesis could be rejected, indicating that there was significance difference in the mean ratings of the three groups. Meanwhile, the Mann-Whitney *U* test was also used to analysis the difference between any two groups.

3.2.2. Fuzzy set theory

Fuzzy set theory is an effective method to identify key factors from a non-normal distribution (Shen et al., 2011). By applying fuzzy set theory, the uncertainty involved and the participants perceived influence on the criticality of the SPIs could be reduced (Zhang et al., 2014). In fuzzy set theory, the symbol $\tilde{A}$ represents a set of key SPIs. A three-step fuzzy set theory process was adopted to identify the KSPIs, including:

1. According to Shen et al. (2011), the probability for a sustainability performance to be included in the KSPI fuzzy set can be described by its degree of membership. The degree of membership can be calculated by:

$$\mu_{\tilde{A}}\left(\chi_{ij}\right) = \int_{3}^{5} f\left(\nu_{xij}\right) \tag{1}$$

where ν_{xij} is the value between 3 and 5 for the sustainability performance χ_{ij} and $f(\nu_{xij})$ represents the frequency of occurrence for the sustainability performance χ_{ij}. The degree of membership $\mu_{\tilde{A}}(\chi_{ij})$ is calculated by summing the frequency $f(\nu_{xij})$, where χ_{ij} has a value between 3 and 5.

2. The survey was obtained from three groups of experts, including governmental agencies, academics and developers. Therefore,

three separate fuzzy sets were created, represented by $\tilde{A}_G$, $\tilde{A}_P$, and $\tilde{A}_D$. Based on the definition of the union operator in fuzzy theory (Zhang et al., 2014), an integrated KSPIs fuzzy set can be obtained by:

$$\tilde{A} = \overline{A_G} \cup \overline{A_P} \cup \overline{A_D} = \left\{ \chi,\ \mu_{\overline{A_G} \cup \overline{A_P} \cup \overline{A_D}}(\chi) | \chi \in X \right\} \tag{2}$$

where:

$$\mu_{\overline{A_G} \cup \overline{A_P} \cup \overline{A_D}}(\chi) = \min\left\{ 1,\ \left[\mu_{\overline{A_G}}(\chi)^p + \mu_{\overline{A_P}}(\chi)^p + \mu_{\overline{A_D}}(\chi)^p \right]^{\frac{1}{p}} \right\}, p \geq 1 \tag{3}$$

where p is the number of factors (42 in this study).

3. The λ-cut set approach is adopted to identify the KSPIs. If the degree membership of $\mu_{\tilde{A}}(\chi_{ij})$ exceeds the threshold value λ, the indicator χ_{ij} will be considered as a KSPI. The value of λ can be set from 0 to 1. If $\lambda = 0$, all indicators will be KSPI. On the other hand, if $\lambda = 1$, all indicators will be non-KSPIs. $\mu_{\overline{A_G}}(\chi_i), \mu_{\overline{A_D}}(\chi_i)\ \mu_{\overline{A_P}}(\chi_i)$ is commonly adopted as the threshold in fuzzy set theory for selecting KSPI (Shen et al., 2011; Zhang et al., 2014).

4. Results

4.1. Criticality of SPIs between-group comparison

As shown in Table 2, the most critical SPI in affordable housing programs from key stakeholder's point of view is financial viability of the programs (SPI1). One interesting finding is that reduced life cycle cost (SPI5) is rated as the least critical SPI, indicating that life cycle costing performance of affordable housing programs in Chongqing is not perceived as a priority compared to the short-term cost performance. Meanwhile, differences exist between different groups when assessing the critical extent of SPIs. For example, while the government group rated cost effectiveness (SPI2) low with a mean score of 2.17, the developer group rated SPI2 high with a mean score of 4.34. This indicates that, for government agencies, cost effectiveness of affordable housing programs may not be as important as it is for developers. As shown in Table 2, the p values of 13 SPIs (SPI5; SPI10; SPI12; SPI14; SPI16; SPI17; SPI24; SPI27; SPI28; SPI32; SPI35; SPI38 and SPI42) are larger than 0.05. This implies that, for the 13 SPIs, there is no significant variance between the three groups of respondents. The p values of the rest 29 SPIs are less than 0.05 which indicates the homogeneity assumption is likely to be violated. Therefore, it is necessary to conduct further analysis.

With regard to the economic sustainability, the results of Mann-Whitney U test indicate that 6 SPIs present significant variance between the groups of governments and developers with p value less than 0.05; 7 SPIs present significant variance between the groups of governments and academics; and 7 SPIs present significant variance between the groups of developers and academics (see Table 3). It is worth noting that 3 SPIs of economic sustainability show no significant variance between any two groups, i.e. SPI5; SPI10 and SPI12, and 2 SPIs of economic sustainability show significant variance between any two groups, i.e., SPI2 and SPI11.

The results of Table 4 imply that 4 SPIs of environmental sustainability present significant variance between the groups of governments and developers with p value less than 0.05; 5 SPIs present significant variance between the groups of governments

Table 2
Mean value, Standard Deviation (SD), and significance value of each Key Sustainability Performance Indicators (KSPIs).

Code	All (N = 102)		Government agencies (N = 29)		Developers (N = 32)		Academics (N = 41)		p value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
SPI1	4.088	0.797	4.448	0.686	4.031	0.933	3.878	0.678	0.007*
SPI2	3.422	1.173	2.172	0.759	4.344	0.745	3.585	0.894	0.000*
SPI3	2.706	1.039	2.448	1.021	2.218	0.870	3.268	0.923	0.000*
SPI4	3.167	1.135	3.621	0.979	2.156	0.884	3.634	0.888	0.000*
SPI5	2.196	0.879	2.414	1.119	2.031	0.822	2.171	0.704	0.412
SPI6	3.618	0.891	4.031	0.739	2.897	0.724	3.805	0.813	0.000*
SPI7	3.235	1.036	3.655	1.009	2.438	0.801	3.561	0.867	0.000*
SPI8	2.294	0.918	2.655	1.045	2.281	0.888	2.049	0.773	0.041*
SPI9	2.882	1.074	2.414	1.119	2.219	0.751	3.732	0.593	0.000*
SPI10	3.677	0.892	3.759	0.951	3.781	1.008	3.537	0.745	0.277
SPI11	3.402	1.196	2.069	1.033	4.063	0.840	3.829	0.704	0.000*
SPI12	2.441	0.896	2.517	1.023	2.313	0.859	2.488	0.840	0.659
SPI13	2.324	0.966	2.552	1.055	2.188	0.859	2.268	0.975	0.000*
SPI14	3.971	0.826	3.966	0.906	4.063	0.948	3.902	0.664	0.525
SPI15	3.009	1.139	2.552	1.055	2.406	0.946	3.805	0.843	0.000*
SPI16	3.804	0.771	3.897	0.772	3.656	0.865	3.854	0.691	0.468
SPI17	2.726	1.073	2.931	1.033	2.656	1.26	2.634	0.942	0.434
SPI18	3.343	1.189	3.759	1.091	2.156	0.808	3.976	0.759	0.000*
SPI19	3.167	1.144	4.035	1.017	2.156	0.808	3.342	0.825	0.000*
SPI20	2.804	1.044	2.586	0.779	2.094	0.856	3.512	0.898	0.000*
SPI21	2.402	0.904	2.379	1.083	2.125	0.707	2.634	0.859	0.000*
SPI22	2.677	1.11	2.103	1.047	2.125	0.833	3.512	0.779	0.000*
SPI23	2.765	0.956	2.310	1.004	2.719	0.991	3.122	0.748	0.002*
SPI24	2.500	1.022	2.241	1.058	2.594	1.043	2.609	0.972	0.19
SPI25	3.461	1.114	3.561	1.049	3.875	0.793	3.585	0.894	0.000*
SPI26	3.324	0.956	3.724	0.959	2.625	0.871	3.585	0.706	0.000*
SPI27	2.392	0.924	2.483	1.089	2.250	0.762	2.439	0.923	0.608
SPI28	2.509	0.983	2.379	0.979	2.594	1.043	2.537	0.951	0.714
SPI29	3.402	0.978	3.759	0.951	2.813	0.931	3.609	0.833	0.000*
SPI30	3.608	0.810	3.897	0.772	3.656	0.787	3.366	0.799	0.022*
SPI31	2.588	0.958	2.276	0.88	2.406	0.946	2.951	0.921	0.006*
SPI32	2.284	0.872	2.241	0.951	2.063	0.801	2.488	0.84	0.097
SPI33	2.824	1.019	2.448	1.021	2.531	1.077	3.317	0.756	0.000*
SPI34	3.206	1.047	3.438	0.759	2.379	1.015	3.609	0.946	0.000*
SPI35	3.882	0.836	4.069	0.799	3.688	0.780	3.902	0.889	0.17
SPI36	2.833	1.127	2.552	1.121	2.125	0.793	2.862	1.274	0.000*
SPI37	2.412	0.968	1.931	0.884	2.688	1.091	2.537	0.809	0.005*
SPI38	2.539	0.961	2.379	1.015	2.813	0.931	2.439	0.923	0.124
SPI39	3.480	0.982	3.931	0.753	2.813	0.896	3.683	0.934	0.000*
SPI40	3.294	1.165	2.241	1.154	3.438	0.914	3.927	0.787	0.000*
SPI41	3.137	0.975	3.517	0.785	2.313	0.896	3.512	0.746	0.000*
SPI42	2.500	0.841	2.345	0.814	2.719	0.958	2.439	0.743	0.175

Note:*the p value < 0.05.

Table 3
Calculation results of Mann-Whitney U test on KSPIs related to economic sustainability.

Code	Government-Developer		Government-Academic		Developer -Academic	
	z	p	z	p	z	p
SPI1	−1.769	0.077	−3.26	0.001*	−1.059	0.289
SPI2	−6.469	0.000*	−5.415	0.000*	−3.525	0.000*
SPI3	−0.909	0.364	−3.054	0.000*	−4.467	0.000*
SPI4	−4.913	0.000*	−0.101	0.92	−5.495	0.000*
SPI5	−1.249	0.212	−0.631	0.528	−0.881	0.379
SPI6	−4.672	0.000*	−0.908	0.364	−0.4296	0.000*
SPI7	−4.304	0.000*	−0.395	−0.693	−0.4774	0.000*
SPI8	−1.431	0.152	−2.505	0.012*	−0.078	0.281
SPI9	−0.574	0.566	−3.153	0.002*	−0.4238	0.000*
SPI10	−0.205	0.838	−1.1175	0.24	−1.503	0.133
SPI11	−5.67	0.000*	−5.894	0.000*	−2.009	0.045*
SPI12	−0.742	0.458	−0.063	0.95	−0.84	0.401
SPI13	−4.834	0.000*	−4.704	0.000*	−0.287	0.774

Note:*the p value < 0.05.

Table 4
Calculation results of Mann-Whitney *U* test on KSPIs related to environmental sustainability.

Code	Government-Developer		Government-Academic		Developer-Academic	
	z	p	z	p	z	p
SPI14	−0.48	0.631	−0.595	0.552	−1.131	0.258
SPI15	−0.475	0.635	−4.573	0.000*	−5.266	0.000*
SPI16	−1.095	0.274	−0.279	0.781	−1.001	0.315
SPI17	−1.059	0.29	−1.201	0.23	−0.173	0.862
SPI18	−4.998	0.000*	−0.745	0.456	−6.58	0.000*
SPI19	−5.616	0.000*	−3.237	0.001*	−5.083	0.000*
SPI20	−2.505	0.012*	−3.954	0.000*	−5.412	0.000*
SPI21	−0.826	0.409	−1.163	0.245	−2.451	0.014*
SPI22	−0.401	0.689	−5.134	0.000*	−5.616	0.000*
SPI23	−1.716	0.086	−3.635	0.000*	−1.66	0.097
SPI24	−1.456	0.145	−1.71	0.087	−0.216	0.829
SPI25	−1.549	0.121	−0.457	0.648	−1.289	0.197
SPI26	−3.98	0.000*	−0.702	0.483	−4.415	0.000*
SPI27	−0.901	0.367	−0.262	0.749	−0.808	0.419
SPI28	−0.76	0.447	−0.667	0.505	−0.168	0.866

Note:*the p value < 0.05.

and academics; and 7 SPIs present significant variance between the groups of developers and academics. Meanwhile, 7 SPIS of environmental sustainability show no significant variance between any two groups, namely SPI14; SPI16; SPI17; SPI 24; SPI25; SPI27 and SPI28. 2 SPIS of environmental sustainability show significant variance between any two groups, namely SPI19 and SPI20. Comparing with economic and social sustainability, more homogeneity has been achieved in the aspect of environmental sustainability.

As to social sustainability, the results of Table 5 suggest that 6 SPIs of social sustainability present significant variance between the groups of governments and developers with p value less than 0.05; 5 SPIs present significant variance between the groups of governments and academics; and 9 SPIs present significant variance between the groups of developers and academics. In addition, 2 SPIs of social sustainability show no significant variance between any two groups, i.e. SPI38 and SPI42 and 1 SPI present significant variance between any two groups, namely SPI40.

4.2. Key sustainability performance indicators

Based on Eq. (1), the degree of membership, $\mu_{\overline{A_G}}(\chi_i)$, $\mu_{\overline{A_D}}(\chi_i)$ and $\mu_{\overline{A_P}}(\chi_i)$ were calculated as shown in Table 6. 17 KSPIs were identified by government agencies. 5 KSPIs are related to economic sustainability, 6 KSPIs were correlated to environmental sustainability and 6 KSPIs were correlated to social sustainability. As to developers, 9 KSPIs were identified. 4 KSPIs are related to economic sustainability, 3 KSPIs were correlated to environmental sustainability and 2 KSPIs were correlated to social sustainability. Comparing with governmental agencies and developers, the academics identified the most with 24 KSPIs. Among this, 8 KSPIs are related to economic sustainability, 9 KSPIs were correlated to environmental sustainability and 7 KSPIs were correlated to social sustainability. It is interesting to note that 7 SPIs were identified as KSPIs by all the stakeholders, namely SPI1, SPI10, SPI14, SPI16, SPI25, SPI30, and SPI35. 10 SPIs were identified as KSPIs by governmental agencies and academics, i.e. SPI14, SPI16, SPI17, SPI18, SPI19, SPI26, SPI29, SPI34, SPI39, and SPI41. 2 SPIs were identified as KSPIs by developers and academics, such as SPI2 and SPI11. Only 5 SPIs were identified as KSPIs by academics, i.e. SPI9, SPI15, SPI19, SPI22, and SPI40.

The integrated degree of membership $\mu_{\tilde{A}}(\chi_i)$ was also calculated using Eqs. (2) and (3). Following the benchmarking of $\lambda = 0.85$, 24

Table 5
Calculation results of Mann-Whitney *U* test on KSPIs related to environmental sustainability.

Code	Government-Developer		Government-Academic		Developer-Academic	
	z	p	z	p	z	p
SPI29	−3.505	0.000*	−0.715	0.475	−3.525	0.000*
SPI30	−1.205	0.228	−2.696	0.007*	−1.571	0.116
SPI31	−0.42	0.674	−2.837	0.005*	−2.486	0.013*
SPI32	−0.634	0.526	−1.334	0.182	−2.114	0.035*
SPI33	−0.242	0.809	−3.1745	0.000*	−3.332	0.001*
SPI34	−3.781	0.000*	−0.802	0.423	−4.408	0.000*
SPI35	−1.904	0.057	0.74	0.459	−1.19	0.234
SPI36	−1.345	0.179	−1.441	0.15	−3.032	0.002*
SPI37	−2.773	0.006*	−2.945	0.003*	−0.643	0.52
SPI38	−1.866	0.062	0.461	0.678	−1.649	0.99
SPI39	−4.448	0.000*	0.919	0.358	−3.838	0.000*
SPI40	−4.073	0.000*	−5.399	0.000*	−2.296	0.022*
SPI41	−4.574	0.000*	−0.13	0.897	−5.051	0.000*
SPI42	−1.764	0.094	−0.459	0.646	−1.502	0.133

Note:*the p value < 0.05.

Table 6
Calculation results for the degree of membership of Key Sustainability Performance Indicators (KSPIs).

Code	Governmental agencies	Developers	Academics	Integrated results
	$\mu_{\overline{A_G}}(\chi_i)$	$\mu_{\overline{A_D}}(\chi_i)$	$\mu_{\overline{A_P}}(\chi_i)$	$\mu_{\tilde{A}}(\chi_i)$
SPI1	1*	0.9375*	1*	1*
SPI2	0.3793	1*	0.8781*	1*
SPI3	0.4828	0.375	0.7805	0.7805
SPI4	0.8966*	0.3438	0.9024*	0.9147*
SPI5	0.4138	0.2813	0.3415	0.4138
SPI6	1*	0.7586	0.9512*	1*
SPI7	0.8621*	0.5	0.8781*	0.8861*
SPI8	0.5517	0.375	0.2683	0.5517
SPI9	0.4483	0.3438	1*	1*
SPI10	0.8966*	0.9063*	0.9512*	0.9556*
SPI11	0.2414	0.9688*	0.9756*	0.9887*
SPI12	0.4828	0.4375	0.5122	0.5132
SPI13	0.4483	0.3438	0.3902	0.4483
SPI14	0.9310*	0.9375*	1*	1*
SPI15	0.5172	0.4688	0.9512*	0.9512*
SPI16	0.9655*	0.9063*	0.9756*	0.9879*
SPI17	0.6552	0.4688	0.5366	0.6552
SPI18	0.8621*	0.3438	1*	1*
SPI19	0.9310*	0.2813	0.8537*	0.9316*
SPI20	0.5517	0.2188	0.8537*	0.8537*
SPI21	0.4483	0.3125	0.5366	0.5366
SPI22	0.2759	0.2813	0.8781*	0.8781*
SPI23	0.3793	0.5938	0.2927	0.5938
SPI24	0.3104	0.5	0.5366	0.5372
SPI25	0.8537*	0.9688*	0.9024*	0.9776*
SPI26	0.8966*	0.5625	0.9512*	0.9530*
SPI27	0.5172	0.375	0.4634	0.5173
SPI28	0.4483	0.5313	0.5122	0.5338
SPI29	0.8966*	0.625	0.9025*	0.9147*
SPI30	0.9655*	0.9375*	0.8781*	0.9717*
SPI31	0.7931	0.4375	0.6829	0.7931
SPI32	0.3448	0.2813	0.4878	0.4878
SPI33	0.4483	0.4375	0.3902	0.4516
SPI34	0.875*	0.3793	0.8781*	0.8912*
SPI35	0.9655*	0.9375*	0.9269*	0.9744*
SPI36	0.4138	0.7813	0.5517	0.8384
SPI37	0.2069	0.5625	0.4878	0.5625
SPI38	0.3793	0.625	0.4390	0.6250
SPI39	1*	0.6563	0.9024*	1*
SPI40	0.3104	0.8438	0.9756*	0.9757*
SPI41	0.8966*	0.4063	0.9268*	0.9317*
SPI42	0.4138	0.3125	0.4390	0.4398

Note:*the degree of membership > 0.85.

KSPIs were identified. Eight KSPIs are related to economic sustainability, i.e. SPI1; SPI2; SPI4; SPI6; SPI7; SPI9; SPI10; and SPI11. 9 KSPIs are related to environmental sustainability, i.e. SPI14; SPI15; SPI16; SPI18; SPI19; SPI20; SPI22; SPI25 and SPI26. 7 KSPIs are related to social sustainability, i.e. SPI29; SPI30; SPI34; SPI35; SPI39; SPI40 and SPI41.

5. Discussions

Based on the above analysis, a sustainability framework is proposed to guide the development of affordable housing. As shown in Fig. 1, there are 24 KSPIs involved in the framework from three aspects of sustainability, i.e. economic, environmental and social.

It is worth noting that affordable housing is one kind of public goods, similar to environmental protection initiatives (Kovacic et al., 2015). As a result, the choice for opting for affordable housing is a public goods game. A typical “tragedy of the commons” dilemma exists where the benefits of one party is on the cost of other parties which eventually leads to overexploitation or degradation of resources in common (Hardin, 1968). For instance, during the decision making process of affordable housing, there are short-term gains to be made in profit by neglecting the environmental issues. However, in the long term the public goods, most notably the environment and natural resources are likely to be lost due to selfish incentives. A number of studies have been undertaken to examine the critical factors to alleviate the tragedy of the commons. For instance, Feeny et al. (1990) argued that institutional and cultural factors should be incorporated into the original model put forward by Hardin (1968). Similarly, the nature of complexity and dynamics should be taken into consideration (Tornell and Velasco, 1992; Milinski et al., 2002). It is well recognized that the agent based modelling provides an effective approach to deal with such social dilemmas (Perc and Szolnoki, 2010; Perc et al., 2013).

5.1. Economic sustainability

Eight KSPIs are in the economic sustainability of affordable housing programs. The financial viability (SPI1) and cost recovery (SPI10) are ranked as the top two KSPIs in economic sustainability by all three groups of respondents. It is also interesting to note that these two KSPIs are not addressed in the affordable housing programs of other countries, such as Australia, Brazil and Nigeria (Azevedo et al., 2010; Ibem and Azuh, 2011; Pullen et al., 2010). This may indicate that these two issues have been well addressed in the affordable housing programs of these countries. However, in China, it has been reported that insufficient funds has caused the suspension of affordable housing projects in many regions. This is partly due to the financial model of Chinese affordable housing programs which largely depend on local governments' investment. Huang (2012) argued that local governments often resist the development of affordable housing programs proposed by the central government because the affordable housing sector is a resource-draining sector to which local government not only provides free land and reduced taxes but also pays for the development and management. Despite the fact that private capital is encouraged to participate in affordable housing programs, low rents and long payback period impede the involvement of private capital in affordable housing projects. For instance, the annual profit of a PRH project developed by Vanke, was only ¥5000 (equivalent to $780) whereas the initial investment was ¥46.24 million (equivalent to $7.23 million) (Chen, 2013).

Three KSPIs are related to housing affordability, including affordable price/renting (SPI4), reduced transportation cost (SPI9) and affordable non-housing cost (SPI11). These three issues demonstrate the importance of non-housing costs in improving housing affordability. Although current affordable housing policies in China focus on addressing housing difficulties of low-income households through housing subsidies or accommodations,

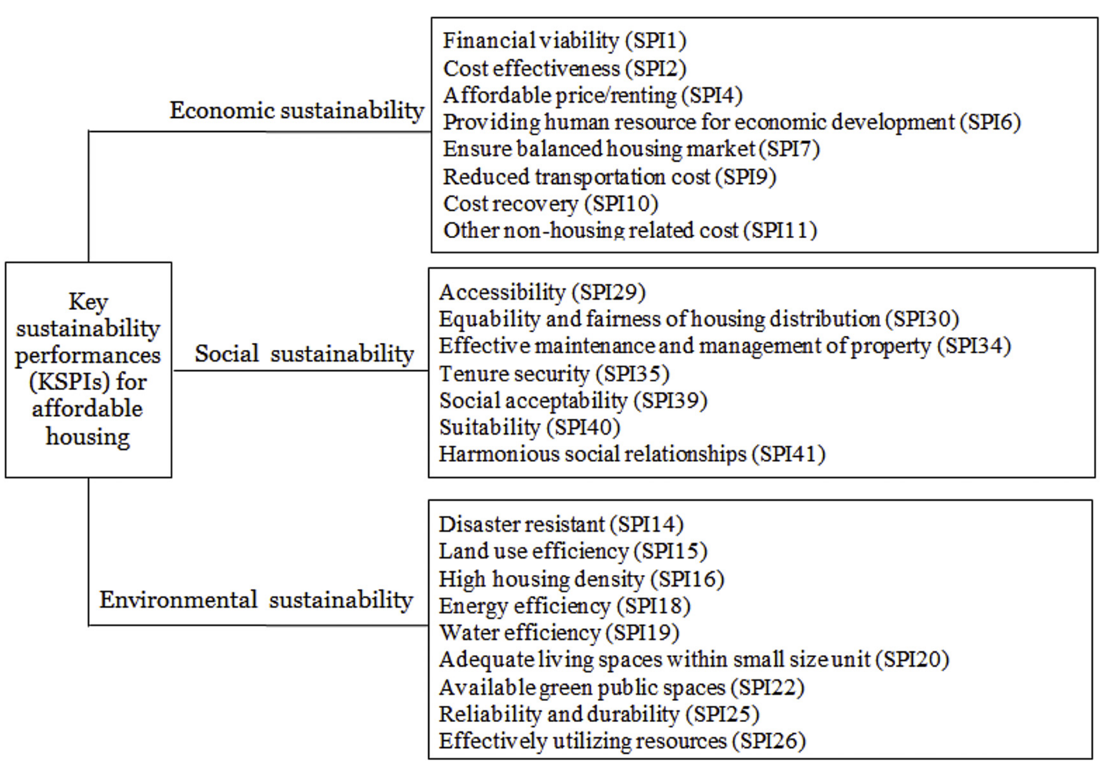

Fig. 1. A framework for the sustainability performance of affordable housing.

research has been conducted on the importance of non-housing costs in affordable housing. For instance, *Opinion on accelerating the renovation of shantytowns* issued by the State Council office highlights that the development SRH should consider employment, health care, education, transportation, supporting facilities and public services (SCGO, 2014). Similarly, *Technical guidelines of green affordable housing* released by MOHURD has requirements on public transport facilities and public services amenities (SCGO, 2013). Although the importance of the non-housing costs in improving housing affordability has been addressed in the related policies of affordable housing, it is worth noting that only SPI4 received a mean value of more than 3 based on the government agencies' opinion on the criticality of the three SPIs. For developers, only SPI11 received a mean value of more than 3. This might imply that the consensus has not been reached on the importance on the three SPIs by three groups of stakeholders, i.e. governmental agencies, developers and academics.

As for the other three KSPIs, cost effectiveness (SP2) is rated as very important by all developers. Similarly, providing human resource for economic development (SP6) and ensuring balanced housing market (SP7) are rated as very important by governmental agencies and academics. With regards to cost effectiveness (SP2), the results of Kruskal-Wallis test and Mann-Whitney *U* test tend to suggest higher degree of criticality of cost effectiveness for developers when compared with other groups. This is mainly because the affordable housing programs in Chongqing are authorized by local government to developers charging for fund, build and manage (Zhou and Ronald, 2016). Meanwhile, Chongqing municipal government imposes a "no profit" policy for the developers of PRH (Zou, 2014). Therefore, cost reduction may be one of the priorities for developers. Meanwhile, it is interesting to note that the other two KSPIs were not highly rated in countries including Australia, Brazil and the U.S. (Azevedo et al., 2010; Pullen et al., 2010; Turcotte and Geiser, 2010). This is arguably due to the fact that, in China, the healthy development of housing market has been negatively affected by unbalanced housing supply and demand that generates "ripple effect" (i.e. house prices change in one area may be felt in other areas) (Zhang and Liu, 2009). As a result, maintaining a balanced housing market has formed an integral part of affordable housing policies, such as the *Notification on the promoting the sustainable and healthy development of real estate market* issued by State Council in 2003 (SCGO, 2003). The massive-scale affordable housing usually erode the profit of developers. As a result, they usually show no enthusiasm. By contrast, the critical role of affordable housing programs for balanced housing market has been well recognized by governmental agencies and academics.

5.2. Environmental sustainability

There are nine KSPIs of environmental sustainability. Among those, two KSPIs, disaster resistance (SPI14) and high housing density (SPI16) are highlighted by the respondents from all groups ($p > 0.05$ in Table 3). This demonstrates the criticality of these two issues in the development of affordable housing in China. Charoenkit and Kumar (2014) suggested the disaster management in developing countries is facing problems such as insufficient disaster protective system and lack of institutional capacity. It is therefore necessary to focus on disaster resistance in the development of affordable housing programs in China. For instance, some requirements have been made by *Technical guidelines of green affordable housing* released by MOHURD, such as the location of affordable housing must avoid risk areas and the geological safety assessment should be completed before construction (SCGO, 2013). One interesting finding is that high housing density, as one KSPI, attracted less or no attention in environmental sustainability rating tools, such as BREEAM (Building Research Establishment Environmental Assessment Methodology) and LEED (Leadership in Energy and Environmental Design). However, high density development is recognized as one important criteria in the environmental assessment rating tools in China, such as the *Assessment Standard for Green Building* and the *Technical Guide for Green Affordable Housing* (SCGO, 2013). This may imply that there is little or no consensus on the degree of housing density in order for the project to be classified as sustainable. As to Chinese cities with high population density and the land resources far below the world average, it is inevitable to increase the housing density of affordable housing. This has been supported by the compact city approach as a form of sustainable urban development (Dempsey et al., 2012).

As for reliability and durability (SPI25), the mean value of this KSP from all the three groups of respondents were higher than 3. This demonstrates the high criticality of this KSPI for the sustainability of affordable housing. It is deserved to find that no interesting of this KSPI is apparent in the Environmental Sustainability Tools mentioned above, such as BREEAM, LEED and the Chinese *Assessment Standard for Green Building*. On contrary, this KSPI was specially highlighted in the *notification of strengthening the quality management of affordable housing projects* (MOHURD, 2011). This might imply that this issue should be intrinsically realized in the housing development without paying much attention on it; however, there has been a poor performance of this KSPI in the affordable housing programs in China. Indeed, it has been reported that the quality problems frequently happened in the affordable housing programs national wide, and some affordable housing projects in the cities of Shenzhen even have to be reconstructed because of poor reliability and durability performance (Liu, 2012). It not only has negative impact to the well-intended of public housing programs but also introduces a large amount of waste in both economic and environmental aspects. Thus, special attentions should be paid on this KSPI in the development of affordable housing programs in China.

Three KSPs with mean criticality rating above 3 have been highly recognized in sustainable or green building rating systems. These three KSPs are energy efficiency (SP18), water efficiency (SP19) and effectively utilizing resources (SP26). These KSPs are the mandatory criteria of building designs in China according to the *Regulations on energy saving for civil buildings* issued by Chinese central government in 2008 (MOHURD & MOF, 2008). However, the results of Kruskal-Wallis test and Mann-Whitney *U* test showed that there are significant differences amongst the three groups' ratings. The mean critically ratings of three KSPs by developers are 2.15 (SP18), 2.15(SP19) and 2.62(SP26), indicating that these KSPs are generally overlooked by developers. As Gan et al. (2015) pointed out, the main reason for developers to overlook these mandatory criteria is related to high initial investments as well as ineffective regulations.

Two SPIs with mean criticality ratings less than 3 (i.e. SPI20: adequate living spaces within small size units and SPI22: available green public spaces) are still classified as KSPIs due to the high ranking from the professional group (both have a mean criticality rating of 3.51). This, however, indicates that government and developers do not pay enough attention to these KSPIs. Poor performance on these two KSPIs can lead to high vacancy rates of affordable housing. For example, 45% of applicants for LongYueJu community, a PRH in LongGang districts, ShenZhen city, finally resign the housing distribution due to poor housing design (such as 4 square meters of bedroom and 1 square meters of bathroom) and inconvenience (e.g. far away from their workplace) (Xiuyu, 2013). Recent regulations have started to take these two KSPs into consideration. For example, in the *Technical Guide for Green Affordable Housing* issued by SCGO (2013), the public green space per capita should reach 1 m^2 and the coverage of green space should be 30% for newly built affordable housing projects. Similarly, the distance to transportation stations, public facilities and services should also be considered.

5.3. Social sustainability

Eight KSPIs have been identified in the aspect of social sustainability. As shown in Table 2, tenure security (SPI35) and equitability and fairness of housing distribution (SPI30) have been ranked as the top two SPIs in social sustainability. The mean value of this two KSPIs from all the three groups of respondents were higher than 3. It is interesting to note that this two KSPIs were not considered as an issue for affordable housing in the countries, such as Australia and Brazil (Azevedo et al., 2010; Pullen et al., 2009), while the two issues are considered as essential for the success of affordable housing projects in China. As to tenure security, it can effectively protect low-income households against violent eviction, and frequent relocations can interrupt work schedules, jeopardize employment and negatively affect the development of children if without considering such security (Abed et al., 2013). Meanwhile, the issue of equitability and fairness of housing distribution has been regarded as one of the reasons leading to insufficient provision of affordable housing in China. For example, it is estimated that 533 units of CRH and ¥4.13 million (equivalent to $0.65million) of rent subsidies were distributed to unqualified households during 2007–2009 (Huang, 2012). Currently, this two KSPIs are highlighted in the affordable housing programs, such as longer contract period of PRH comparing with private rental housing and the procedure of "application-screening-public display-waiting in turn" has been introduced for CRH and PRH (MOHURD, 2014).

Three KSPIs, social acceptability (SPI39), accessibility (SPI29) and suitability (40) focused on the buildings or neighborhood environment. The result is consistent with the related policies of Chinese affordable housing programs, such as the *Notification on Strengthening the Quality Management of Affordable Housing Projects* (MOHURD, 2011), *Design Rules and Technical Measures of PRH* and *Decoration and Design Code for Affordable Housing* (CQCC, 2010). These regulations not only emphasize the importance of both housing quality and comfortable living within compact housing areas, but also highlight suggest the supporting facilities should be synchronously planned, constructed and delivered with affordable housing projects. However, it is interesting to find that little attention has been paid by developers on the KSPI of accessibility (mean rating < 3). Developers often struggle with time, budget and land use constraints in affordable housing projects (Golubchikov and Badyina, 2012). It is indeed a challenge to timely provide adequate supporting facilities in new affordable housing developments especially in developing countries (Golubchikov and Badyina, 2012).

The other two KSPs are related to the services and social relationships of affordable housing, namely effective maintenance and management of property (SP34) and harmonious social relationships (SP41). These two KSPs are considered as important by government agencies and academics (mean rating >3). This probably indicates the critical role of governments in achieving the two KSPs. It is not unusual residents of the PRH are unsatisfied with the services and management. Due to low property management fee, low-income households in Asia often experience poor facilities management and services (Charoenkit & Kumar, 2014). Indeed, it presents significant challenges to engage professional facilities management for high quality services in affordable housing programs. Meanwhile, more public services are needed because residents of affordable housing are mostly less privileged or facing huge social pressure (Yan, 2013). In order to address the issue, some improvements have been made by local governments. For instance, Chongqing municipal government established a dedicated administrative authority for the operation of affordable housing. According to the *Further strengthening the facility management of affordable housing* issued by BMHOURD (2015) (Beijing Commission of Urban-Rural Development), property management companies should meet the minimum qualification threshold in order to bid for the facility management work of public housing programs. In addition, a community management system of affordable housing has been established as it can satisfy the demands of residents in a timely manner. Such strategies not only effectively improve the service quality provided by facility management companies but also promote the social connections within the affordable housing community.

6. Conclusions

Large-scale construction of affordable housing offers an important opportunity to incorporate sustainability into the housing developments in Mainland China. Incorporating sustainability into affordable housing not only increases housing affordability for low-income households but also demonstrates the future of affordable housing programs. Although the incorporation of sustainability was mentioned in a few policies, there is a lack of sustainability framework to guide the development of affordable housing. This paper, therefore, introduces a set of key sustainability performance indicators for decision making in affordable housing programs. 24 KSPIs were identified from economic, environmental and social dimensions of sustainability. Related to this, some KSPIs were highlighted by this research but were overlooked in other countries such as financial viability, cost recovery, providing human resource for economic development, ensuring balanced housing market, high housing density, reliability and durability, tenure security and equitability, and fairness of housing distribution.

The incorporation of sustainability into affordable housing developments helps to achieve the sustainable development at the regional scale. By adopting these KSPIs into project feasibility study, project planning and project post-evaluation, a systematic integration of sustainability into affording housing programs can be achieved. Despite this, 17 KSPIs' criticality judged by different groups of stakeholders with significant variances indicate no consensus have been reached on these KSPIs. It is worth noting that all the 17 KSPIs were overlooked by developers but emphasized by governmental agencies and academics. According to this, it can be concluded that little attentions have been paid by developers on incorporating sustainability into affordable housing programs. This is probably attributed to the construction mode of affordable housing programs in Chongqing as the developers are responsible for the finance, construction and management under "no profit" policy.

There are some policies implications from this study. Firstly, incorporating sustainability into affordable housing programs should be in place with a consideration of local context as well as the economic and social situation. Some issues of sustainability were highlighted by this research but overlooked by other studies. Secondly, it is imperative to engage various stakeholders as different perception of criticality are found from government, developers and academics on various sustainability performance indicators. A consensus on the critical extent of these sustainability issues needs to be achieved prior to initiating the development of affordable housing programs. Therefore, an effective communication mechanism should be established amongst various stakeholders by using the tool of multi-objective group decision-making. Thirdly, incentives should be provided by government for developers. This can be set as showcase for incorporating sustainability into housing developments. Meanwhile, preferential economic policies, such as lower land prices, tax reduction, and so on, could be accessed to developers in not only affordable housing programs but also other housing developments. As a result, the developers will be motivated to incorporate sustainability into affordable housing developments.

A limitation of this study is the evaluation of criticality of KSPIs is based upon perceptions of three key stakeholders in affordable housing developments, i.e. governmental agencies, developers and academics. Future research opportunities exist to investigate perceptions of other key stakeholders such as residents. Similarly, case studies could be undertaken to investigate the sustainability performance of affordable housing projects. Findings of this study were drawn from a specific geographical context, i.e. Chongqing. Further studies could be conducted to investigate similar issues in other contexts and to examine the effects of contextual factors. Other potential future research directions include: tradeoffs amongst various sustainability indicators from various stakeholder's perspectives, and examining indicators used in normal practice.

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