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Bridging the Gap between Sustainable Housing and Affordable Housing: The Required Critical Success Criteria (CSC)

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Abstract

Studies on specific critical success criteria (CSC) for performance measurement of sustainable affordable housing projects are limited. This study aims to identify and classify the various CSC from the views of affordable housing experts around the world. 21 CSC were identified from a comprehensive literature review followed by a questionnaire survey on the identified 21 CSC. With 51 responses, the data were analyzed. Factor analysis indicated that the various CSC can be grouped into six components: household satisfaction CSC, stakeholders' satisfaction CSC, house operation cost CSC, time measurement CSC, location affordability cost CSC and quality-related CSC. Practically, the findings of this study can serve as a guide for assessing the performance of affordable housing projects as well as serving as a guide to developers, NGOs and government agencies in the allocation of resources for the provision of sustainable affordable housing. Future study would investigate the interrelationship between critical success criteria and critical success factors for sustainable affordable housing.

Keywords: Critical Success Criteria; Affordable housing; Sustainable housing; Affordability

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1. Introduction

Housing is among the basic social conditions which define the quality of life and wellbeing of the citizens of any nation. However, in a constantly changing and urbanizing world, housing supply has not been able to adequately meet demand (Gan et al., 2017). Corollaries of the acceleration in urbanization are increasing affordability challenges among low income earners noted in both developed and developing countries (Dezhi et al., 2016). For instance, it has been estimated that the number of poor people living in shantytowns and sub-standard housing in developing countries is 828 million. Speculations are that this number will increase to 1.4 billion by 2020 (Al-Saadi and Abdou, 2016; Desai, 2012; Gan et al., 2017). A survey conducted among some developed countries such as USA, Australia, Singapore, Hong Kong (China), New Zealand and Ireland revealed that out of 293 housing markets surveyed, only 63 were considered affordable (Cox et al., 2017). In general, the anticipation of the world's population growth from 3.6 billion to 6.3 billion in 2050 is an indication that more housing will be required to meet the mounting housing needs (Golubchikov and Badyina, 2012). Accordingly, sustainable affordable housing remains a priority for all governments and other policy makers.

Many affordable housing policies have been initiated. However, whether the housing affordability of low-income earners has been improved remains a debate (Gan et al., 2017). Study by Stone (2006) has focused on the economic measure - price affordability - for accessing the success or improvement of housing policies. Conversely, by solely focusing on the economic measure, real estate developers, planners, architects and governments have encountered challenges of low demand and abandonment of housing in the provision of affordable housing (Susilawati and Armitage, 2005; Adabre and Chan, 2018). For example, in a developing country China, it was stated that the average housing price-to-income ratio for many major cities was 10.2 in 2013, which situated China in a group of severely unaffordable housing market (Zhang et al., 2016). However, public rental housing which were less than 30% of market rents were abandoned by applicants in Shenzhen, Wuhan, Nanjing, Zhengzhou and Shanghai (Lin, 2012). Consequently, 90% vacancy rate was reported in the case of Shenzhen (Yuan et al., 2018). In Malaysia, a study indicated the need for affordable housing for low and middle-income earners (Abdul-Aziz and Kassim, 2011). Yet, affordable housing that were supplied to these income categories were left vacant leading to housing overhang (Teck-Hong, 2012). A Similar situation of housing abandonment has been reported in a developed country United Kingdom (Mulliner et al., 2013). In all these cases, the abandonments of the houses were attributed to other criteria beyond price affordability. Thus, these paradoxes of housing needs amidst housing overhangs buttress the fact that not all that is affordable is sustainable! Therefore, bridging the gap between sustainable housing and affordable housing is exigent.

Successively, in a study conducted by Mulliner et al. (2013), it was concluded that in addition to economic measures, there are non-economic criteria associated with evaluating success of sustainable affordable housing projects. These economic and non-economic criteria or standard are termed critical success criteria (CSC). CSC are the set of principles or standards through which judgement can be made whereas critical success factors (CSF) are the set of circumstances, facts or influences which affect / contribute to the results or CSC (Lim and Mohammed, 1992 p.243). For instance, 'accessibility to shops' and 'access to health services' are examples of CSFs (factors) whereas 'reduced commuting cost or time' could be used as a CSC (criterion / outcome) which is influenced by the CSFs. Furthermore, 'availability of green public space' is a CSF whereas 'household / stakeholders' satisfaction' and 'quality housing' could be used as CSC (Torbica and Stroh, 2001; Ahadzie et al., 2008). Moreover, 'the construction method for a housing facility' and 'materials used for construction' are CSFs which could influence CSC such as 'maintainability of a housing facility'; 'technical specification of a housing facility' and 'environmental performance of a housing facility' (Torbica and Stroh, 2001; Rankin et al., 2008). Finally, 'the type of communication among project stakeholders' could be a CSF which influences criteria such as 'reduced occurrence of disputes and litigation among project stakeholders' and 'technology transfer' in construction projects (Adinyira et al., 2014).

In addition to the lack of consensus on CSC (Gan et al., 2017), studies on CSC for sustainable affordable housing projects are limited. As such, an investigation on CSC for sustainable affordable housing projects is important for the following reasons. Knowledge on CSC is required for the development of sustainable and affordable housing policies to improve the current and anticipated affordability crises. Besides, real estate developers, governments and international organizations need to be apprised of the effective and appropriate CSC to identify affordability challenges and innovate measures for successful housing delivery. Moreover, CSC serve as measures to guide developers and governments to enhance efficient allocation of the limited resources to meeting the residential needs of the household (Chua et al., 1999). Finally, the categorization of the various CSC will help governments and international policy makers on strategies required to bridge the gap between sustainable housing and affordable housing.

In the light of the background above, the main objective of this study is to identify the CSC which are required to evaluate success in sustainable affordable housing projects. Therefore, a literature review was conducted to identify the potential set of CSC for sustainable affordable housing projects, which forms section two of this study. Then, Section Three presents a thorough description of the research methodology adopted for the study. Furthermore, statistical analysis of the survey responses together with discussion of results was conducted in the penultimate section, Section Four. Finally, some concluding remarks are stated in Section Five.

2. Literature Review

The identification of key project CSC is important so that construction managers, project managers and policy makers can appropriately plan resource allocation (Chua et al., 1999). Irrespective of the type of construction projects, the iron triangle of time, cost and quality have been widely recognized as the fundamental CSC in many studies (Atkinson, 1999; Bassioni et al., 2004; Chan and Chan, 2004). However, it is a fact that some determinants of success are likely to be distinctive among projects. Moreover, studies have revealed that the iron triangle criteria are non-exhaustive (Lim and Mohamed, 1999; Pinto and Pinto, 1991; Pocock et al.,1996). Therefore, studies have been conducted to comprehensively identify CSC for project monitoring and control in the construction industry (Lim and Mohammed, 1999; Baccarini, 1999; Ahadzie et al., 2011; Al-Tmeemy et al., 2011).

In general construction project, Lim and Mohamed (1999) explored the criteria of project success from different perspectives of stakeholders. The identified criteria were grouped into two categories. These included the macro and micro perspectives. Project completion and satisfaction were the criteria that defined the macro viewpoint of project success while the micro viewpoint was solely defined by the completion criterion. Thus, the classification by Lim and Mohamed (1999) highlighted an overlap between the categories. For instance, the completion criterion was common to both the macro and micro viewpoints. The other criterion – satisfaction – was more focused on the owner and user of the project. Therefore, they failed to provide detail criteria for construction companies or contractors (Al-Tmeemy et al., 2011). In Baccarini (1999), the criteria of project success were grouped into product success and project management success based on the goal, purpose, output and input. The product success deals with goals and purpose while the project management success deals with output and inputs. Although Baccarini (1999) flagged some key criteria applicable to construction companies and contractors in the project management success criteria, contractors' goals such as revenue and profit, market share and competitive advantage were not explicitly stated. Based on this knowledge gap, Al-Tmeemy et al. (2011) conducted a study on developing a framework to categorize project success for building projects from contractors' perspectives. While maintaining the classification of Baccarini (1999), Al-Tmeemy et al. (2011) added another category of success – market success. Therefore, three classes of project success were identified from the study of Al-Tmeemy et al. (2011). These included: the project management success which consists of adherence to quality targets, schedule and budget; the product success such as customer satisfaction, functional requirement and technical specification; market success such as revenue and profit, market share, reputation and competitive advantage. The market success criteria emphasised on the strategic goals of construction companies.

Although the identified criteria from previous studies (Lim and Mohammed, 1999; Baccarini, 1999 and Al-Tmeemy et al., 2011) are comprehensive and applicable to most construction projects, not all might be relevant for housing projects due to differences in project characteristics. For instance, according to Ahadzie et al. (2008) on mass housing, housing projects involve the construction of domestic residence. Moreover, mass housing projects are speculative in nature since decisions on land acquisition, design and construction of such houses are mostly made without a specific customer in mind. Therefore, with regard to housing projects, Ahadzie et al. (2008) developed four clusters of CSC for mass housing projects: environmental impact, customer satisfaction, quality and overall cost and time. These CSC could be appropriate for affordable housing projects based on the similarities between mass housing and affordable housing. Like mass housing, affordable housing projects involve the construction of domestic residence and are also speculative in nature. Despite the similarities in project characteristics, definitional difference between them suggests that the CSC for mass housing are not comprehensive CSC for affordable housing projects. In Ahadzie et al. (2008 p. 678), mass housing is defined as "the design and construction of speculative standardized house-units usually in the same location and executed within the same project scheme." However, "affordable housing is housing that is reasonably adequate in standard and location for a lower or middle-income household and does not cost so much that such a household is unlikely to be able to meet other basic living costs on a sustainable basis (National Summit on Housing Affordable, 2006). The rule-of-thumb is that housing is affordable if low income household spent less than 30% of their income on housing. Therefore, mass housing projects are affordable provided they meet the affordability criteria / requirements. Otherwise, mass housing cannot be considered affordable housing and therefore different CSC maybe required for assessing the sustainability of affordable housing.

Findings of the study by Ahadzie et al. (2008) cannot be considered as complete CSC for affordable housing projects. For example, price of housing and rental cost of housing in relation to household income which are important criteria for affordable housing (Mulliner et al., 2013) were not considered among the criteria in their study. Besides, transportation cost in relation to the income of households (Isalou et al., 2014) was also not listed among the criteria identified in their study. Based on these caveats, it is necessary to find out the exclusive CSC for sustainable affordable housing projects. Studies have been conducted on identifying these specific criteria. The traditional ratio criterion measures affordability in terms of the ratio of housing cost to income. However, Chaplin et al. (1994) and Bogdon and Can (1997) stated that though the ratio approach is simple to compute and widely used, it is not adequate enough to assess the affordability situation of household. Affordability must involve whether a household has enough income left over for other needs of life after paying housing bills. If the household cannot meet their non-housing needs such as food, medical care and clothing at some minimum level of adequacy after paying for housing bill, then the household is 'shelter poor'. Thus, unlike the ratio criterion which looks at housing affordability only as a matter of housing cost, the 'shelter poor' or 'residual' approach takes into account the full amount required for housing and other basic needs (Stone, 2006). However, the residual income approach and the shelter poverty concept have a practical challenge of being translated into an operational affordability scale. It is a problem setting the minimum standard of adequacy for non-shelter items (Bogdon and Can, 1997). Moreover, the conventional ratio and residual approaches focus more on the economic issues of price affordability of housing. This solely does not bridge the gap between sustainable housing and affordable housing. For example, though the prices of a housing facility might be affordable, it is not truly affordable if it located in a remote area with high transportation cost (Golubchikov and Badyina, 2012). In a study conducted by Isalou et al. (2014), it was found out that suburban household spent about 57% of their income on housing and transportation which was significantly higher compared to 45% of housing and transportation expenditure spent by households in the urban areas.

Yet, the price of a housing facility and transportation cost do not give a complete view of the required CSC for measuring the success of sustainable affordable housing projects (Mulliner et al., 2013; Gan et al., 2017). According to Mulliner et al. (2013 p. 270), to improve quality of life and community sustainability, aside the economic assessment criteria, "the environmental and social sustainability of housing must be taken into consideration". Using the COPRAS method of Multi-Criteria Decision Making (MCDM), twenty-one criteria were used to assess the affordability of an area. These criteria in descending order of their mean scores include: house price in relation to income, rental costs in relation to income, interest rates and availability of mortgages, social and private rented accommodation availability, homeownership products availability, access to employment opportunities, public transport services accessibility, quality school accessibility, access to shops, access to health services, access to child care, open green public space accessibility, quality of housing, energy efficiency of housing, availability of waste management facilities, appeal of neighborhood area, deprivation in area and presence of environmental problems. It was concluded that considering social and environmental criteria can critically influence the estimation of the affordability in an area as compared to focusing solely on the financial criteria. Although Mulliner et al. (2013) broadened the scope of sustainable affordable housing criteria and contributed significantly, they failed to differentiate critical success criteria (CSC) from critical success factors (CSFs). Out of the twenty-one criteria, only five criteria namely, house price in relation to income, rental costs in relation to income, safety (crime), quality of housing and energy efficiency can be termed as critical success criteria. However, the other 16 criteria are critical success factors (Lim and Mohamed, 1999).

Similarly, Gan et al. (2017) aimed at identifying key sustainability performance indicators (KSPIs) from three stakeholder groups such as developers, government and academics. Using the fuzzy set theory and variance analysis, 24 KSPIs were conclusively highlighted from 42 sustainability indicators of affordable housing. Among the KSPIs, some of the CSC include affordable price / rent, reduced transport cost, cost effectiveness and energy efficiency. However, like in previous study by Mulliner et al. (2013), some of the 24 identified indicators are possibly critical success factors rather than critical success criteria. For instance, 'providing human resource for economic development', 'ensure balance housing market', 'availability of green public space and adequate living space within small size unit' are critical success factors (Lim and Mohamed, 1999).

It can be concluded from the above literature review that studies on CSC for bridging the gap between sustainable housing and affordable housing are limited. Therefore, a comprehensive investigation of CSC for performance assessment of sustainable affordable housing and for bridging the gap between sustainable housing and affordable housing is worthwhile.

3. Research Methodology

3.1 Establishing Potential CSC for Sustainable Affordable Housing

To establish the relevance of the various CSC for sustainable affordable housing, a thorough review of the literature on CSC was first conducted. Consequently, a set of 20 CSC that are apposite for sustainable affordable housing was developed. Then a pilot study was conducted by sending out the list of CSC to affordable housing experts with sufficient research and / or industrial experience. This was carried out to review the completeness and clarity of the CSC. Both experts from academia and industry confirmed the comprehensiveness of the CSC with minor corrections on the appropriateness of the words to convey meaning without ambiguity. Moreover, the criterion - waiting time of applicants before being allocated a housing unit – was suggested by one of the experts and upon further consultation with other experts and reading of the literature, it was added. Therefore, a total of 21sustainable affordable housing CSC were established. These are presented in Table 1 with their respective references.

Table 1: Potential CSC for Sustainable Affordable Housing

No.	CSC for Sustainable Affordable Housing	References
CSC01	Timely completion of project	Chan and Chan (2004); Bassioni et al. (2004); Ahadzie et al. (2008)
CSC02	Construction cost performance of housing facility	Al-Tmeemy et al. (2011); Osei-Kyei and Chan (2017)
CSC03	Quality performance of project	Atkinson (1999); Lim and Mohamed (1999); Cox et al. (2003)
CSC04	Safety performance	Wai et al. (2012); Kylili et al. (2016); Ngacho and Das (2014)
CSC05	End user's satisfaction with the housing facility	Torbica and Stroh (2001); Bryde and Robinson (2005)
CSC06	Project team satisfaction with the housing facility	Yan et al. (2018)
CSC07	Environmental performance of housing facility (Eco-friendly)	Lim and Mohamed (1999); Atkinson (1999); Rankin et al. (2008)
CSC08	Reduce life cycle cost of housing facility	Wai et al. (2012); Ahadzie et al. (2008)
CSC09	Maintainability of housing facility	Wai et al. (2012)
CSC10	Energy efficiency of housing facility	Wai et al. (2012); Ahadzie et al. (2008)
CSC11	Reduced occurrence of disputes and litigation	Osei-Kyei and Chan (2017)
CSC12	Reduced public sector expenditure on managing housing facility	Osei-Kyei and Chan (2017)
CSC13	Functionality of housing facility	Chan and Chan (2004); Chan et al. (2002)
CSC14	Technical specification of housing	Chan and Chan (2004); Osei-Kyei and Chan (2017);
CSC15	Aesthetically pleasing view of completed house	Chan and Chan (2004)
CSC16	House price in relation to income	Mulliner et al. (2013); Ahadzie et al. (2008)
CSC17	Rental cost in relation to income	Mulliner et al. (2013)
CSC18	Commuting cost from the location of housing to public facilities	Hamidi et al. (2016)
CSC19	Technology transfer	Ahadzie et al. (2008)
CSC20	Waiting time of applicants before being allocated a housing unit	Chiu (2007)
CSC21	Take up rate of housing facility (marketability of housing facility)	Pullen et al. (2010)

3.2 Data Collection

A questionnaire survey was conducted for data collection from affordable housing experts around the world. Questionnaire survey has been used to seek professionals' views in construction related research (Chan et al., 2018). These experts were selected based on two major criteria as used in previous studies (Ke et al., 2011; Osei-Kyei and Chan, 2017).

1. Respondents who had broad research and / or industrial experience in affordable housing were selected
2. Respondents who have in-depth knowledge on affordable housing projects were contacted to participate in the survey.

Considering the selection criteria for experts, it is believed that these experts will offer insight on the relevance of the CSC for sustainable affordable housing projects.

The targeted respondents for this survey included experts in academia, contractors or developers and consultants. Experts were sourced and identified from affordable housing related publications in top-tier academic refereed journals and databases (member directories) of affordable housing experts. Like snowballing, potential respondents of the questionnaire were implored to forward the questionnaire to any affordable housing expert they deemed suitable to answer the questionnaire. Therefore, it will be a herculean task to state the exact number of questionnaires administered. However, approximately 200 questionnaires were administered. Emails were sent to the participants with the questionnaire attached together with a web-link option for responding to the questionnaire through a "survey monkey". These flexibility options provided convenient means for experts to respond to the questionnaire to enhance the response rate. Experts were asked to rate on a five-point Likert scale (1= not important, 2= less important, 3= neutral, 4= important, 5= very important) the level of importance of each CSC in measuring success in sustainable affordable housing projects. Fifty-three responses were received. However, two respondents skipped most of the questions on the CSC and were therefore excluded from the number of responses, lowering the number of responses to 51 with a response rate of 26%. Despite the low response rate, the sample size is deemed appropriate for further analysis when compared with the response rate of previous study (Zhang, 2004). Besides, low response rate is not unusual with online questionnaire surveys. For instance, Osei-Kyei and Chan (2017) received 42 responses out of 310 participants (a response rate of 18%). As argued in Chan et al. (2018), a minimum sample size of 30 is regarded as representative of the population. Moreover, despite the small sample size, the aim of the study could be achieved. Table 2 shows the number of responses received from various countries. It shows that most of the responses are from the United States of America, Australia, Malaysia and Italy

Table 2. Responses from Various Countries

Countries	Number of Response
USA	12
Australia	5
Malaysia	5
Italy	4
Hong Kong	3
Sweden	3
China	3
Canada	3
Ghana	2
New Zealand	2
Singapore	2
Brazil	1
India	1
Spain	1
South Africa	1
Japan	1
Norway	1
Papua New Guinea	1
Total	51

3.3 Profiles of Respondents

Table 3 is a summary of the profile of respondents. Most of the respondents (72.5%) are in the category of academia / research institute followed by respondents in the consulting firms (9.8%). About 5.9% and 3.9% of the respondents are public sector agencies and private developers / contractors, respectively. With regard to profession, most of the respondents are researchers (54.9%) as shown in Table 3. Many of the respondents (41.2%) had over 20 years of experience in affordable housing projects. Generally, all the respondents indicated that they have been involved in affordable housing research and /or have industrial experience with affordable housing projects.

A summary of the research framework for the study is shown in Fig. 1. It reveals the stages, research process, research methodology and findings for the study.

Table 3: Respondents' Category, Profession, Years of Experience and Housing Type Handled

Category, Profession, years of experience and housing type handled	Number of Response	Percent
Category		
Academia / research institute	37	72.5
Consulting firm	5	9.8
Public sector agency / department	3	5.9
Private developer /contractor	2	3.9
Others	4	7.8
Profession		
Academic / researcher	28	54.9
Architect	9	17.6
Quantity Surveyor	3	5.9
Project / Construction manager	2	3.9
Engineer	1	2.0
Others	8	15.7
Years of Experience		
1-5 years	9	17.6
6-10 years	11	21.6
11-15 years	6	11.8
16-20 years	4	7.8
> 20 years	21	41.2
Housing Type Handled		
Social housing	37	40.2
Public housing	35	38.0
Cooperative housing	14	15.2
Others	6	6.5

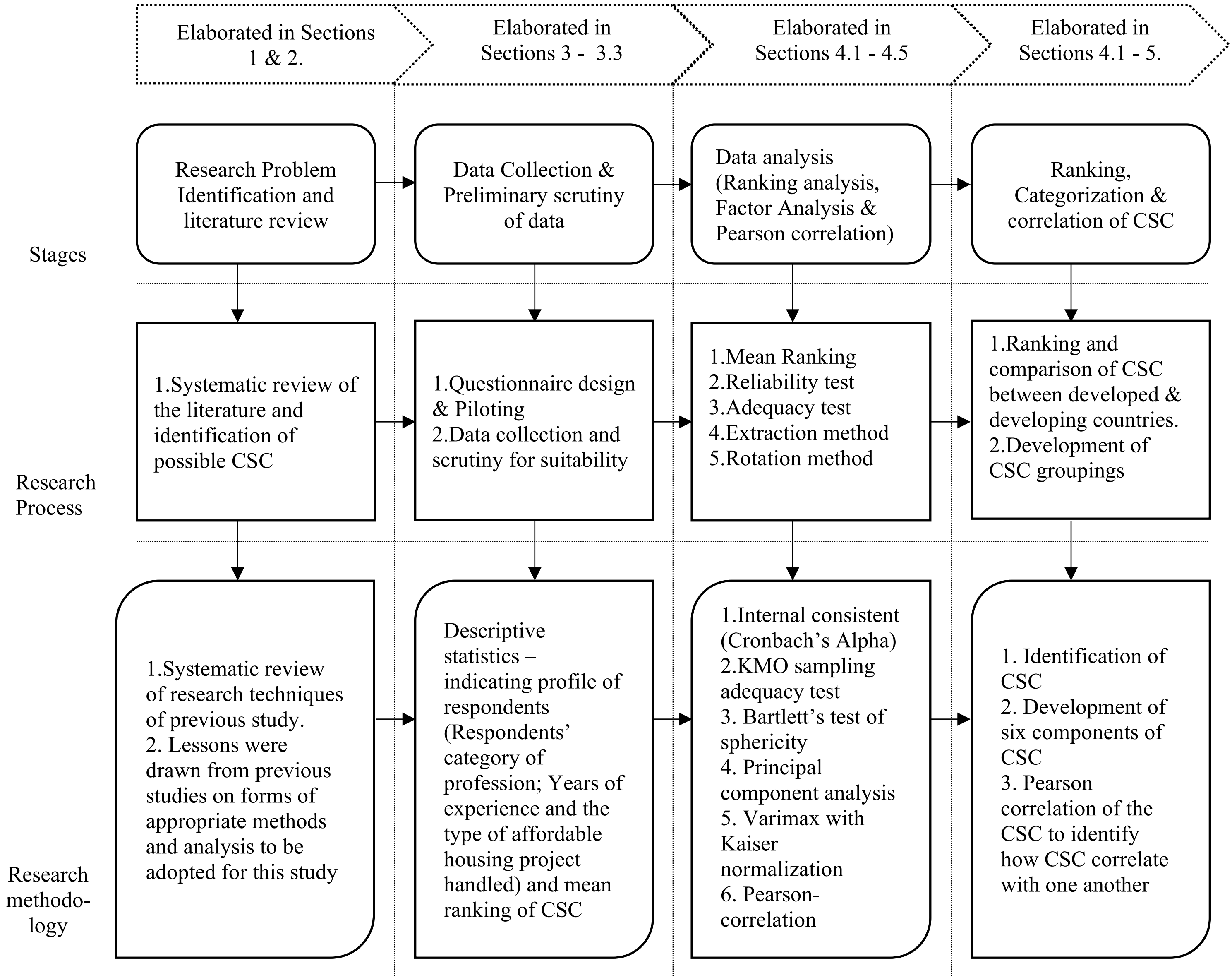

Fig 1: Research Framework for the Study

4. Data Analysis and Results

The Statistical Package for Social Science (SPSS) version 20 was used to conduct statistical analysis of data. Three statistical analyses were conducted: descriptive analysis, factor analysis and Pearson Correlation, as shown in Fig. 1. Before conducting the statistical analysis, the internal consistency reliability and how well the set of 21 CSC are correlated to one another were checked using the Cronbach's Alpha (α). A Cronbach's Alpha of 0.720 was obtained. According to Field (2013), a Cronbach's alpha of 0.70 is considered acceptable. Therefore, the Cronbach's alpha gives indication that the 21 CSC are internally consistent and well correlated to one another. Then, the descriptive analysis was used for ranking the various criteria based on their computed means and standard deviation values. Moreover, the Pearson correlation analysis was employed to determine how each CSC correlated with one another. Finally, factor analysis was conducted using all the 21 CSC to reduce them into components or categories of

CSC that could be measuring the same underlying effect (Ahadzie et al., 2008). The steps in the analysis, findings and discussions are presented in subsequent sections.

4.1 Mean Ranking of CSC

The CSC were ranked based on their mean and standard deviation values (shown in Table 4). The ranking is first based on the mean values of the CSC. However, if two or more CSC have the same mean the CSC with the lowest standard deviation is ranked the highest. The top five CSC for responses from all countries include house price in relation to income (CSC16), rental cost in relation to income (CSC17), maintainability of housing facility (CSC9), end user's satisfaction with housing facility (CSC5) and functionality of housing facility (CSC 13) with mean scores of 4.833, 4.771, 4.553, 4.417 and 4.333, respectively.

The high ranking of price and rental cost of housing implies that though the other criteria are necessary for sustainable affordable housing, priority is most centered on price and rental affordability. Similarly, in Gan et al. (2017) price and rental affordability were highly ranked by different stakeholders namely government agencies, developers and academics. Therefore, improvement in any of the CSC, that is likely to increase price and rental affordability of housing could be resisted. This was confirmed by a study conducted by Chan et al. (2018) in which increase in cost was among the main reasons for the low adoption of green building technologies in both developed and developing countries. Therefore, Chan et al. (2018) concluded that cheaper and efficient green building technologies should be adopted to improve the level of success of the other criteria in housing projects (i.e. reduce life cycle cost of housing facility and energy efficiency of housing facility) without increasing price and rental cost of housing. The five least ranked CSC from all responses include: reduced public sector expenditure on house management (CSC12), reduced occurrence of disputes and litigation (CSC11), project team satisfaction (CSC6), technical specification of housing (CSC14) and technology transfer (CSC 19) which all had mean values below 3.700. Similarly, in Ahadzie et al. (2008) technology transfer was the least ranked critical success criterion.

Furthermore, the means, standard deviation and ranking were calculated separately for both developed and developing countries. Classification of countries into developed and developing countries was done with reference to data from Mandelli et al. (2016). China, Malaysia, Ghana, Papua New Guinea, South Africa, India and Brazil were grouped as developing countries while USA, Australia, Italy, Hong Kong, Sweden, Canada, New Zealand, Singapore, Spain, Japan and Norway were classified as developed countries. Among the developed countries, priority was given first to rental cost of housing and then house price. However, in developing countries, price of housing was ranked first while rental cost was ranked forth. In Gilbert (2016), it was stated that the privatization of public housing due to abysmal low rents, self-help housing and the cultural preference for ownership among developing countries could be the reasons for the preference of price affordability over rental affordability. From the findings (as shown in Table 4), other CSC such as commuting cost from location of housing facility to public facilities, maintainability of housing facility and reduce lifecycle cost were ranked relatively high among developed countries as compared to their rankings from developing countries. It is not surprising given the disparities in the ranking of these sustainability related criteria. This reflects the high priority devoted to these criteria from developed countries as compared to developing countries (Darko et al., 2018).

Table 4: Ranking of CSC

Code	All Countries			Developed Countries			Developing Countries		
	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank
CSC16	4.833	.429	1	4.857	.430	2	4.769	.439	1
CSC17	4.771	.425	2	4.857	.355	1	4.539	.519	4
CSC09	4.553	.503	3	4.559	.504	3	4.539	.519	4
CSC05	4.417	.613	4	4.343	.639	4	4.615	.506	3
CSC13	4.333	.724	5	4.286	.750	6	4.462	.660	8
CSC03	4.313	.689	6	4.171	.707	10	4.692	.480	2
CSC02	4.313	.748	7	4.286	.789	5	4.385	.650	9
CSC04	4.292	.544	8	4.200	.531	9	4.539	.519	6
CSC08	4.250	.700	9	4.229	.690	7	4.308	.751	14
CSC18	4.250	.758	10	4.200	.797	8	4.385	.650	9
CSC10	4.167	.694	11	4.086	.612	12	4.385	.870	12
CSC20	4.167	.883	12	4.086	.951	11	4.385	.650	9
CSC01	4.042	.898	13	3.886	.932	13	4.461	.660	7
CSC21	4.000	.905	14	3.882	.946	14	4.364	.674	13
CSC07	3.854	.684	15	3.800	.719	15	4.000	.577	18
CSC15	3.833	.753	16	3.743	.741	16	4.077	.760	17
CSC12	3.688	1.095	17	3.543	1.146	17	4.078	.862	16
CSC11	3.583	.964	18	3.429	.948	18	4.000	.913	20
CSC06	3.575	.853	19	3.412	.857	19	4.000	.707	19
CSC14	3.521	.875	20	3.286	.789	20	4.154	.801	15
CSC19	3.065	1.020	21	2.971	.937	21	3.333	1.231	21

4.2 Factor Analysis

Factor analysis was conducted to group the 21 CSC into components. This was necessary to identify the underlying structures of CSC for sustainable affordable housing projects. The Principal Component Analysis (PCA) was adopted for the factor analysis. Prior to conducting the analysis, the suitability of the data for factor analysis was assessed. The Kaiser-Meyer-Olkin (KMO) Sampling Adequacy Test and Bartlett's Test of Sphericity were carried out to determine the data appropriateness. KMO measures the sampling adequacy as a ratio of the squared correlation between the variables to the squared partial correlation between the variables (Field, 2013). KMO value of 0 is an indication of the unsuitability of data for factor analysis while a value of 1 indicates that the data are suitable and will yield reliable and distinct factors in the factor analysis. A KMO value above 0.5 is deemed appropriate (Field, 2013). Table 5 shows the test results. The KMO measure of sampling adequacy was 0.63. Thus, this was considered acceptable. Besides, the Bartlett Test of Sphericity was conducted to check if the original correlation matrix is an identity matrix. For data suitability for factor analysis, the Bartlett's test of sphericity must be large with a small associated significance level (Pallant, 2013). The Bartlett's test of Sphericity was 483.120 at a significance level of 0.000. This indicates that the population correlation matrix was not an identity matrix (Larose, 2006; Field, 2013). Therefore, the test results of the KMO and Bartlett's Test suggested that the data were suitable for factor analysis.

With the selection of the Varimax Rotation, the Principal Component Analysis was then carried out to identify the fundamental structures of CSC. Conventionally, only variables with eigenvalue and factor loading at cut-off points of 1.0 and 0.50, respectively, were retained. Since the factor loadings for all the CSC exceeded 0.50 (Shown in Table 7), all the 21 CSC were retained. "The relatively high values of the loading factors (0.6 for more than four variables) lend support to the favorability of the sample size for the analysis" (Ahadzie et al. 2008 p. 681). Six components were extracted (as shown in Table 7). The total variance explained by each component (as shown in Table 7) is as follows: Component 1 (29.377%); component 2 (13.103%); component 3 (10.317%); component 4 (7.868%); component 5 (6.790%) and component 6 (5.271%). In sum, the components explained 72.726% of the total variance.

Depending on the underlying variables in each component, the components were named as follows: component 1 was named 'Household satisfaction CSC'; component 2: Stakeholders' satisfaction CSC; component 3: House operation cost CSC; component 4: Time measurement CSC; component 5: Location affordability cost CSC; component 6: Quality-related CSC.

Table 5: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.630
Bartlett's test of sphericity	Approximate chi-square	483.120
	df.	210
	Sig.	0.000

Table 6: Correlation Matrix of CSC

CODE		CSC01	CSC02	CSC03	CSC04	CSC05	CSC06	CSC07	CSC08	CSC09	CSC10	CSC11	CSC12	CSC13	CSC14	CSC15	CSC16	CSC17	CSC18	CSC19	CSC20	CSC21
CSC01	**r**	**1.000**																				
CSC02	**r**	.392**	**1.000**																			
CSC03	**r**	.116	.343*	**1.000**																		
CSC04	**r**	.105	.189	.433**	**1.000**																	
CSC05	**r**	.161	.174	.441**	.521**	**1.000**																
CSC06	**r**	.361*	.047	.124	.230	.393**	**1.000**															
CSC07	**r**	-.094	-.200	.370**	.231	.402**	.365*	**1.000**														
CSC08	**r**	.051	.173	.232	.140	.397**	.393**	.389**	**1.000**													
CSC09	**r**	-.005	.269	.293*	.415**	.487**	.206	.415**	.559**	**1.000**												
CSC10	**r**	.193	.020	.200	.263	.233	.442**	.590**	.569**	.384**	**1.000**											
CSC11	**r**	.414**	.155	.072	.358*	.192	.365*	.132	.284	.156	.297*	**1.000**										
CSC12	**r**	.252	.252	.076	.192	.040	.082	-.062	.271	.208	.098	.479**	**1.000**									
CSC13	**r**	.240	.314*	.469**	.450**	.591**	.084	.186	.210	.459**	.226	.264	.080	**1.000**								
CSC14	**r**	.540**	.429**	.430**	.389**	.301*	.597**	.272	.339*	.352*	.449*	.364*	.204	.324*	**1.000**							
CSC15	**r**	.136	.019	.389**	.433**	.200	.455**	.447**	.363*	.422**	.420**	.313*	.116	.104	.490**	**1.000**						
CSC16	**r**	-.202	.033	-.108	.030	-.135	-.200	-.157	.142	-.057	.095	.034	.339*	-.160	-.274	-.022	**1.000**					
CSC17	**r**	-.253	-.239	-.041	.111	.048	-.219	-.044	.125	.009	.132	-.082	-.112	.115	-.302*	-.122	.369**	**1.000**				
CSC18	**r**	.172	.122	.255	.438**	366*	-.030	.113	.281	.303*	.243	.349*	.507**	.426**	.056	.186	.261	.248	**1.000**			
CSC19	**r**	.263	.291	.254	.206	-.008	.323*	.274	.327*	.232	.305*	.495**	.437**	.033	.518**	.483**	.026	-.227	.150	**1.000**		
CSC20	**r**	.045	-.145	.192	.339*	.498**	.354*	.358*	.344*	.367*	.231	.333*	.231	.111	.106	.426**	.075	.161	.350*	.160	**1.000**	
CSC21	**r**	-.045	-.102	.226	.458**	.404**	.150	.331*	.214	.101	.249	.312*	.115	.193	.116	.273*	.341*	.325*	.398**	.218	.640**	**1.000**

r =Value for Pearson correlation.
p= Value of the significance
*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

(**CSC01** = Timely completion of projects; **CSC02** = Construction cost performance of housing facility; **CSC03** = Quality performance of project; **CSC04** = Safety performance; **CSC05** = End user's satisfaction with the housing facility; **CSC06** = Project team satisfaction with the housing facility; **CSC07** = Environmental performance of housing facility (Eco- friendly); **CSC08** = Reduced life cycle cost of housing facility; **CSC09** = Maintainability of housing facility; **CSC10** = Energy efficiency of housing facility; **CSC11** = Reduced occurrence of disputes and litigation; **CSC12** = Reduced public sector expenditure on managing housing facility; **CSC13** = Functionality of housing facility; **CSC14** = Technical specification of housing; **CSC15** = Aesthetically pleasing view of completed house; **CSC16** = House price in relation to income; **CSC17** = Rental cost in relation to income; **CSC18** = Commuting cost from the location of housing to public facilities; **CSC19** = Technology transfer; **CSC20** = Waiting time of applicants before being allocated a housing unit; **CSC21** = Take up rate of housing facility (marketability of housing facility))

Table 7: Rotated Component Matrix

Code	CSC for Sustainable Affordable Housing	Components Loading					
		1	2	3	4	5	6
Component 1: Household Satisfaction CSC							
CSC13	Functionality of housing facility	0.839	–	–	–	–	–
CSC5	End user's satisfaction with the housing facility	0.812	–	–	–	–	–
CSC9	Maintainability of housing facility	0.641	–	–	–	–	–
CSC4	Safety performance (crime)	0.610	–	–	–	–	–
Component 2: Stakeholders' Satisfaction CSC							
CSC1	Timely completion of project	–	0.788	–	–	–	–
CSC6	Project team satisfaction	–	0.688	–	–	–	–
CSC11	Reduced occurrence of disputes and litigation	–	0.607	–	–	–	–
Component 3: Housing Operation Cost CSC							
CSC10	Energy efficiency of housing facility	–	–	0.856	–	–	–
CSC8	Reduced lifecycle cost of housing	–	–	0.842	–	–	–
CSC7	Environmental performance of housing facility (Eco-friendly)	–	–	0.530	–	–	–
Component 4: Time Measurement CSC							
CSC21	Take up rate of housing facility (marketability of housing facility)	–	–	–	0.802	–	–
CSC20	Waiting time of applicants before being allocated housing unit	–	–	–	0.716	–	–
CSC2	Construction cost performance of housing facility	–	–	–	-0.555	–	–
Component 5: Location affordability Cost CSC							
CSC12	Reduced public sector expenditure on house management	–	–	–	–	0.818	–
CSC16	House price in relation to income	–	–	–	–	0.649	–
CSC18	Commuting cost from the location of housing to public facilities	–	–	–	–	0.631	–
CSC17	Rental cost in relation to income	–	–	–	–	0.506	–
Component 6: Quality-Related CSC							
CSC3	Quality performance of project	–	–	–	–	–	0.686
CSC15	Aesthetically pleasing view of completed house	–	–	–	–	–	0.665
CSC19	Technology transfer	–	–	–	–	–	0.658
CSC14	Technical specification of housing	–	–	–	–	–	0.600
Eigenvalue		6.169	2.752	2.167	1.652	1.426	1.107
Variance (%)		29.377	13.103	10.317	7.868	6.790	5.271
Cumulative Variance (%)		29.377	42.480	52.797	60.665	67.455	72.726

Extraction Method: Principal Component Analysis; **Rotation method**: Varimax with Kaiser Normalization

4.3 Results of Principal Component Analysis and Discussion

4.3.1 Component 1: Household Satisfaction CSC

The underlying CSC in this component highlight the criteria that lead to household satisfaction in a housing facility. This component is characterized by four main criteria. These four CSC, together with the percentages of their loading in bracket include: functionality of housing facility (83.9%); end user's satisfaction with housing facility (81.2%); maintainability of housing facility (64.1%) and safety performance (61.0%). This component explains most of the variance among the six components, about 29.377% (please refer to Table 7 for loading and for the variance).

The correlation matrix (shown in Table 6) revealed significant associations among the various CSC in this component. For example, the correlation between 'functionality of housing facility' and 'end user's satisfaction' was significant (r=0.591, p=0.01); between 'functionality of housing facility' and 'maintainability of housing facility' (r= 0.459, p=0.01) and 'functionality of housing facility' and 'safety performance' (r=0.450, p=.0.01). Therefore, the association among these CSC is coherent since they measure the same factor – household satisfaction.

Similarly, in Ahadzie et al. (2008), household satisfaction with housing facility emerged as one of the components for mass housing projects. To bridge the gap between sustainable housing and affordable housing, meeting household satisfaction is very important. Household satisfaction is defined as an assessment of the degree to which the current dwelling of the household and quality of the environment are close to the expectations of their favorite one (Galster, 1985). Ensuring functionality of housing according to aspirations, safety performance (i.e. security provision features) and ease of housing facility maintenance are relevant for household satisfaction. Functionality is considered a consequence of the facility. It includes the performance output and the benefits of the facility to the household. Performance output of housing facility measures the quality of the housing while the benefit of the housing functionality is a measure of the household satisfaction (Jusan, 2007). Functionality can be measured by the level of conformance to client's expectation, with the ultimate goal of achieving fitness for purpose (Chan et al., 2002). Functionality should be assessed at the post construction phase, when the facility is completed and is in use (Chan et al., 2002).

Moreover, several features of a house ensure residential satisfaction. For instance, separate bedrooms for parents and children contribute to more private space and residential satisfaction (Ren and Folmer, 2017). Similarly, Pearson's correlation conducted by Mohit et al. (2010) revealed that residential satisfaction is highly and positively correlated with dwelling unit features followed by the social environment, dwelling support services and public facilities. Among planning policies, neighborhood interaction and safety were dominant predictors of residential satisfaction. Moreover, maintainability of a housing facility ensures household satisfaction. In Torbica and Stroth (2001), low-cost maintenance features of house and ease of home maintenance were identified as contributory variables for household satisfaction.

Although Riazi and Emami (2018) found that design principles on residential satisfaction had a significant value of 0.183, most of the design features were related to safety and security provisions. Some of these features include lighting of public areas, safety of car parking, safety of outdoor parking, safety of indoor space and security for children in public areas. Personal security was identified as a feature that first-time homebuyers look out for in making purchasing decision. Crime rate in the neighborhood and whether a neighborhood is gated are significant factors that influence residential satisfaction and the likelihood of home ownership among first-time homebuyers (Teck-Hong, 2012). Safety community together with good leisure facilities promote residential satisfaction (Ren and Folmer, 2017).

4.3.2 Component 2: Stakeholders' Satisfaction CSC

This component consists of 'timely completion of project' (78.8%), 'project team satisfaction' (68.8%) and 'reduced occurrence of dispute and litigation' (60.7%). These three CSC explained about 13.10% of the total variance (as shown in Table 7).

The construction of an affordable housing project involves many stakeholders including the targeted households, governments, developers, design team, suppliers and the people in the neighborhoods of the project. Stakeholders receive and execute the success criteria. Therefore, they have the potential to impact the outcome of sustainable affordable housing project (Yan et al., 2019). Findings of the study showed that there is a statistically significant correlation between 'timely completion of project' and 'reduce occurrence of disputes' (r=0.414, p=0.01) (as shown in Table 6). According to Sambasivan and Soon (2007), most disputes in construction projects are the effects of project delays. Timely completion of projects prevents construction disputes that could arise from construction claims. Besides, decrease in property values due to affordable housing projects is one of the causes of public protest which has caused the failure of many affordable housing projects (Nguyen et al., 2013; Tighe, 2010). Delays and complete abandonment of projects due to political reasons could affect the values of neighboring housing facilities. Such projects are often used as hideouts for criminals. As such, households in the neighborhood might live in fear of insecurity. Therefore, potential tenants and buyers might perceive such surroundings as unsafe. This could lower the rent and price of the neighboring facilities. This leads to dissatisfied neighborhoods who may disrupt and protest against the construction of subsequent affordable housing project. Accordingly, timely completion of affordable housing projects ensures stakeholders' satisfaction by preventing negative social impacts. It also ensures project team satisfaction (Rashvand and Zaimi Abd Majib, 2013). This is evident in the statistically significant correlation (as shown in Table 6) between 'timely completion of project' and 'project team satisfaction' (r=0.361, p=0.05). Similarly, 'reduced occurrence of disputes' and 'project team satisfaction' have a statistically significant association (r=0.365, p=0.05).

4.3.3 Component 3: Housing Operation Cost CSC

The total variance accounted by component 3 is 10.3% (as shown in Table 7). The respective criteria and the percentage of the factor loadings in this component include energy efficiency (85.6%), reduced lifecycle cost of housing facility (84.2%) and environmental performance of housing facility (53.0%) (as shown in Table 7). The criteria showed significant correlation among themselves. The correlation (as shown in Table 6) between energy efficiency and reduced lifecycle cost of housing was significant (r=0.569, p=0.01); the correlation between energy efficiency and environmental performance was also significant (r=0.590, p=0.01). Similarly, reduced life cycle cost and environmental performance of housing facility revealed a significant correlation (r=0.389, p=0.01). These significant associations among these criteria are not surprising because according to Ruparathna et al. (2016), the environmental impact of a housing facility is determined from its lifecycle and its energy consumption. Since all these criteria measure the operation cost or impact of a housing facility (Pacheco et al., 2012), this component was, accordingly, named as housing operation cost CSC.

For sustainable affordable housing, the operations cost of housing is worth considering due to its cost saving benefits to low income household and the environment. Minimizing the operation cost of affordable housing projects could be achieved through energy efficient housing. The fundamental principle of energy efficient housing is to use the minimum energy for operation (such as cooling, lighting, heating etc.) without impacting residents' health and comfort (Ruparathna et al., 2016). Improving energy efficiency of affordable housing is key to abating the environmental effects – greenhouse effects – due to CO_2 emissions. It also reduces the energy use and therefore provides economic benefits such as savings to low-income earners. Moreover, energy efficient affordable housing is a requirement to prevent fuel poverty – low income household spending beyond 10% of their income on domestic energy (Mattioli et al., 2018).

Studies have been conducted on energy efficient technologies that can be adopted to provide sustainable affordable housing without rendering household shelter poor (Allouhi et al., 2015; Morrissey et al. 2011; Nikolaidis et al., 2009). On the mechanical components of a housing facility, heating, ventilation and air conditioning (HVAC) system is the most energy consumption component of a housing facility (Perez-Lombard et al., 2011). Using thermal solar systems for a substitute of an electric water heater leads to 80% saving of the cost of heating water as well as ensuring environmental protection (Nikolaidis et al., 2009). By changing from air-cooled to water cooled air-conditioning system, substantial electricity consumption could be reduced (Yik et al. 2001).

With regard to lighting system, about 15% of the total energy of a building is spent on lighting. However, installing better luminous efficacy lamps and linking daylight to lighting systems could reduce electricity consumption on lighting. Moreover, changing to light emitting diode (LED) light system, replacing incandescent lamps with low energy fluorescent lamps and installing automated lighting system can reduce the amount of electricity demanded for lighting (Ruparathna et al., 2016). Another important area for energy efficient housing is the building envelope. Improved Insulation minimizes the heat gain or loss from a building thereby enhancing the thermal performance of the housing facility (Ruparathna et al., 2016). Reflective paint and coating on roofs and walls or insulating paint with low conduction can be used to improve the thermal performance of a building. In a location of high temperature difference between day and night, coating of the external surface of the housing facility provides better thermal function. However, in locations of low temperature difference between daytime and nighttime, housing facilities with interior insulation do better (Huang et al., 2013).

Building codes set the lowest requirement for energy efficiency in buildings. Notable ones include BREEAM, Leadership in Energy and Environment (LEED) and Green Star. These codes may target one of the following building energy concepts: low energy building, passive houses, zero energy building, zero carbon building (Allouhi et al., 2015). By making building energy code mandatory, it was stated that the yearly electricity consumption, for example in Hong Kong, can be lowered by 7.9% (Lee and Yik, 2002). Therefore, through the development of localized codes or adoption of internationally recognized codes, affordable housing would be energy efficient and thus sustainable.

The shape of a housing facility affects the amount of solar radiation that the building receives, which consequently influences its total energy consumption (Mingfang, 2002). The higher the solar radiation received by a housing unit, the higher the energy required to cool it (Elasfouri et al., 1991). According to Aksoy and Inalli (2006), 36% of heat energy savings can be obtained by combining the optimization of orientation and shape of a building. For instance, on quantifying the effects of a building shape on the amount of energy required to heat and cool a building, Florides et al. (2002) concluded that the best orientation to maximize the solar benefits of a rectangular building is for the lengthiest wall of the housing unit to face the south.

The southern orientation is best for heat gain during wintertime and for regulating solar radiation during summer (Pacheco et al., 2012). Shading on buildings also affects the amount of solar radiation gain by a building. For instance, overhangs over windows prevent the direct entry of solar radiation through the window, therefore, it regulates the entry of excessive heat and daylight. However, since overhangs are mostly designed to remain fixed, they could favor energy savings in certain times while hindering energy saving at a different time. Thus, mobile shading devices provide better energy saving benefits than immovable shading devices (Bouchlaghem, 2000). Using the net present value appraisal on a uniform evaluation period, Nikolaidis et al. (2009) found that insulation of the roof of a building provides better intervention concerning heat insulation than with the replacement of windows and doorframes, which yielded low returns on investment.

Moreover, though mud / baked bricks cannot be used to construct structural elements, its use for the construction of non-loading bearing walls could offer energy saving benefits. According to Chel and Tiwari (2009), internal temperatures of mud houses are moderate throughout the year. This leads to potential energy savings. Mud houses have yearly heating and cooling energy saving of about 1481KWh/year and 1813kWh, respectively. Moreover, mud-houses can alleviate 5.2 metric tons per year of CO_2 emission into the atmosphere.

4.3.4 Component 4: Time Measurement CSC

The extracted CSC with their factor loading for this component include 'take up rate of housing facility (marketability)' (80.2%), 'waiting time of applicants before being allocated housing unit' (71.6%) and 'construction cost performance of housing facility' (-55.5%). This cluster explained about 7.87% of the total variance (as shown in Table 7) and was named time measurement CSC.

The correlation matrix (shown in Table 6) revealed that significant correlations exist among the criteria in this component. For example, the correlation between 'take up rate of housing facility' and 'waiting time of applicant before being allocated a housing unit' was significant ($r=0.640$, $p= 0.01$). Since both criteria measure the time taken for a household to move into a housing facility, the significant correlation between them is logical.

Aside building affordable housing, it is important to measure how supplied housing is reducing the time spent by low-income earners in the 'waiting line' before being allocated affordable housing unit. Besides, assessing how affordable housing supplies are meeting the needs of household is very critical. This can be measured using the take-up rate of housing facilities. Houses that are affordable but not adequate and sustainable are likely to receive low take-up rate by low income earners (Teck-Hong, 2012). Take up rate of an affordable housing facility is significantly associated with household's satisfaction ($r=0.404$, $p=0.01$). The correlation between take up rate and household's satisfaction indicates that high expectation for household satisfaction leads to high take-up rate of a housing facility. However, high cost of housing facility beyond the affordability range of the household could lead to low take up rate of the housing facility and increase waiting time of applicants for housing unit allocation.

4.3.5 Component 5: Location Affordability Cost CSC

The principal component 5 contains four CSC: reduced public sector expenditure on housing management (81.8%); house price in relation to income (64.9%); commuting cost from the location of housing to public facilities (63.1%) and rental cost in relation to income of household (50.6%) (as shown in Table 7). This component accounted for 6.79% of the total variance (as shown in Table 7). Studies have stated that affordability should be measured as location affordability, that is taking into consideration housing affordability cost and cost of transportation or accessibility (Kramer, 2018; Mattioli et al., 2018; Fan and Huang, 2011). Therefore, this component was labelled location affordability cost CSC.

As shown in the correlation matrix in Table 6, a statistically significant correlation exists between 'house price in relation to income' and 'rental cost in relation to income' (r=0.369, p=0.01). This association between the two criteria is reasonable since both are used to measure the same item – housing affordability. Similarly, there was a significant correlation between the criteria 'reduced public sector expenditure on house management' and 'commuting cost from the location of housing to public facilities' (r=0.507, p=0.01).

Previous studies have elaborated on the importance of housing affordability (Adinyira et al., 2014; Ahadzie et al., 2008). However, an important cost factor which was overlooked in measuring affordability is the cost of transportation. Location affordability incorporates both the cost of housing and transportation. A study conducted by Saberi et al. (2017), revealed that neighbourhoods that seem to be affordable with regard to only housing cost are not definitely affordable when transportation cost is factored in. Housing facilities at the urban peripheral or in low-residential density areas may appear more affordable yet might suffer from inadequate access to various amenities and incur high cost on transportation in order to access the amenities. Thus, the low housing cost is mostly offset by the high commuting cost which leads to transport poverty. A household might be transport poor based on three conditions: if the household spends more than 10% of their income on car running costs, if the household lives more than one mile from the closest bus or station and if it takes more than one hour to access a number of important services by cycling, walking and public transport (Sustrans, 2012 cited in Mattioli et al., 2018). Transportation poverty has many effects. Individuals can be rendered unemployed due to inability to afford ownership of cars / commuting cost. Besides, most households that are able to afford do trade-off transport expenditure against spending on other necessities (Mattioli et al., 2018).

It is recommended that policies and plans for housing affordability should take into account transportation infrastructure supply (Saberi et al., 2017). Three main factors influence transportation affordability namely the built environment, policy environment and the socio-demographics of households (Fan and Huang, 2011). The socio-demographics of the household defines the influence of household income on transportation affordability. The built environment (defined by the land use) and urban design influence the transportation affordability. There is an association between the built environment and travel behavior. For instance, low residential density and mono-functional use of land are related to more car travel. However, high density areas such urban centers where the buildings are closer, walking and cycling would be encouraged among many households especially low-income earners (Mattioli et al., 2018). It is worth noting that extreme cases of compact city and urbanization could increase traffics on the roads thereby increasing the time spent on travelling. Thus, an affordable house is not sustainable if the cost and time of transportation are very high.

4.3.6 Component 6: Quality-Related CSC

Lastly, the sixth principal component contains four CSC. These CSC together with their factor loading are 'quality performance of project' (68.6%), 'aesthetically pleasing view of completed house' (66.5%), 'technology transfer' (65.8%) and 'technical specification of housing' (60.0%). This component explains 5.3% of the total variance and is named quality-related CSC.

The findings revealed that some of the four CSC in this component showed statistically significant correlation among themselves. For instance, the correlation matrix (as shown in Table 6) revealed a significant relationship between quality performance of project and aesthetically pleasing view of completed house (r=0.389, p=0.01). Besides, the correlation between quality performance of project and technical specification of housing was significant (r=0.430, p=0.01). Moreover, the correlation matrix revealed a significant association between 'technology transfer' and 'technical specification of housing' (r=0.518, p=0.01). Likewise, the association between technology transfer and aesthetically pleasing view of completed house is significant (r=0.483, p=0.01).

The significant association between quality performance and aesthetically pleasing view of completed house could be attributed to the fact that the conventional description of quality is based on issues such as 'how well a housing facility blends into its environment', 'the facility's psychological impacts on its inhabitants', 'the ability of landscaping plan to match the theme of nearby structures' and 'the use of intriguing novel design models that capture people's imaginations' (Stasiowski and Burstein, 1994). Since the aesthetic definition of quality is subjective, there is often no consensus on whether quality affordable housing has been achieved or not (Arditi and Gunaydin, 1997). However, quality performance of housing facility can also be defined objectively as meeting technical specification of the designer, owner and regulatory organizations (Ferguson and Clayton, 1988).

Due to the subjective and objective assessment of quality, it is important to differentiate 'quality in perception' and 'quality in fact'. A housing facility that meets client's and household's expectation attains quality in perception while a housing facility that meets the technical specification attains 'quality in fact' (Arditi and Gunaydin, 1997). 'Quality in fact' can be achieved by meeting two main requirements: product quality and process quality (Arditi and Gunaydin, 1997). Whereas product quality is ensuring suitable construction materials, equipment and technology required for the construction of a housing facility, process quality involves attaining quality with regard to the design and construction of the housing facility. Achieving both forms of quality is very important. The neglect of quality in perception has often resulted in abandon affordable housing facilities (Arditi and Gunaydin, 1997; Teck-Hong, 2012). Therefore, it is suggested that prior to the construction of any housing facility, a pilot study should be conducted to assess the needs of the intended households. Regular assessment of the needs of the intended households is important since household needs are ephemeral (Adabre and Chan, 2018). This assessment will ensure that the expected quality of a household is met. Though quality is considered a latent variable, it could be achieved based on the housing design features. Design principles such as interior layout (i.e. size of living room, arrangement of rooms, size of kitchen, availability of storage room) and privacy of living space (i.e. number of bedrooms, size of bedrooms and number of bathrooms) are considered very important among low-income households (Opoku and Abdul-Muhmin, 2010). Among interior design features such as number of bedrooms, bathrooms and living rooms, living space was the indicator of quality that had the highest loading and reliability (Ren and Folmer, 2017). Thus, these quality features should be taken into consideration for sustainable affordable housing projects so as to meet household needs.

The significant positive correlations among technology transfer, technical specification and aesthetically pleasing view of housing (as shown in Table 6) are logical. In Adinyira et al. (2014) technology transfer emerged together with cost of individual units. Accordingly, it was stated that the benefits of technology transfer could improve the price affordability of housing facilities. In this study, technology transfer emerged together with quality performance of housing project, aesthetically pleasing view of completed house and technical specification of housing. This implies that aesthetically pleasing view and technical specification could be improved through technology transfer.

4.4 Relevance and Integration of the Six Components of CSC

Based on the empirical data, six main components are essential for making affordable housing sustainable. The attainment of the six components of CSC will ensure that the three main aspects of sustainability – economic, social and environment – are achieved in affordable housing projects. For instance, household satisfaction CSC, time measurement CSC, quality-related CSC and stakeholder's satisfaction CSC measure success with regard to social sustainability in housing projects. These CSC for social sustainability are essential for ensuring good-quality, secure and healthy housing facilities (Dang et al., 2014). The four components of CSC for social sustainability are interdependent. Quality-related CSC could lead to the achievement of both household satisfaction CSC and stakeholders' satisfaction CSC. Besides, quality-related CSC could influence high residential take up – one of the time measurement CSC. A high residential take up rate indicates that the housing facilities are appreciated by the target household (Chen et al., 2014) whereas a low residential take up of affordable housing facilities may indicate that the housing facilities need to be improved or other facilities need to be provided to meet household needs. Accordingly, the CSC for social sustainability play an important role in improving the operational performance of affordable housing projects (Yuan et al., 2018).

Economic sustainability in affordable housing projects could be measured using the location affordability cost CSC (Isalou et al., 2014). These criteria are essential for assessing the success of price / rental and commuting cost affordability of housing facilities. Commuting cost of residents plays a tremendous role on household income (Gan et al., 2017). High commuting cost could cause high cost burden on household income thereby worsening housing affordability of households. The CSC for economic sustainability are interdependent on the CSC for social sustainability and environmental sustainability. For instance, low location affordability cost CSC due to high accessible locations of housing facilities reduces transportation cost which could influence household satisfaction CSC, stakeholders' satisfaction CSC and time measurement CSC (Yuan et al., 2018). Besides, low location affordability cost CSC due to accessible location of housing facilities conserves energy and reduces pollution emission (such as carbon dioxide and carbon mono-oxide), which improves on environmental sustainability (Isalou et al.,2014).

Housing operation cost CSC (such as energy efficient housing facilities, reduced lifecycle cost of housing facility and environmental performance of housing facility) are essential for environmental sustainability attainment in affordable housing projects. The housing operation cost CSC measure the impacts of housing facilities on the environment. The construction, maintenance and use of housing facilities involves the consumptions of an enormous amount of scarce energy and other resources. These could lead to high environmental depletion. However, using energy efficient technologies and environmental friendly materials could improve environmental sustainability of affordable housing projects (Golubchikov and Badyina, 2012).

Based on the aforementioned components of CSC, bridging the gap between sustainable housing and affordable housing requires the following six components of CSC: (1) household satisfaction CSC, (2) stakeholders' satisfaction CSC, (3) housing operation cost CSC (4) time measurement CSC, (5) location affordability cost CSC, (6) quality-related CSC. To summarize, a framework of sustainable affordable housing can therefore be established as shown in Fig. 2, which includes the six components of CSC which are essential for sustainable affordable housing. These components are interdependent with important relationships among them.

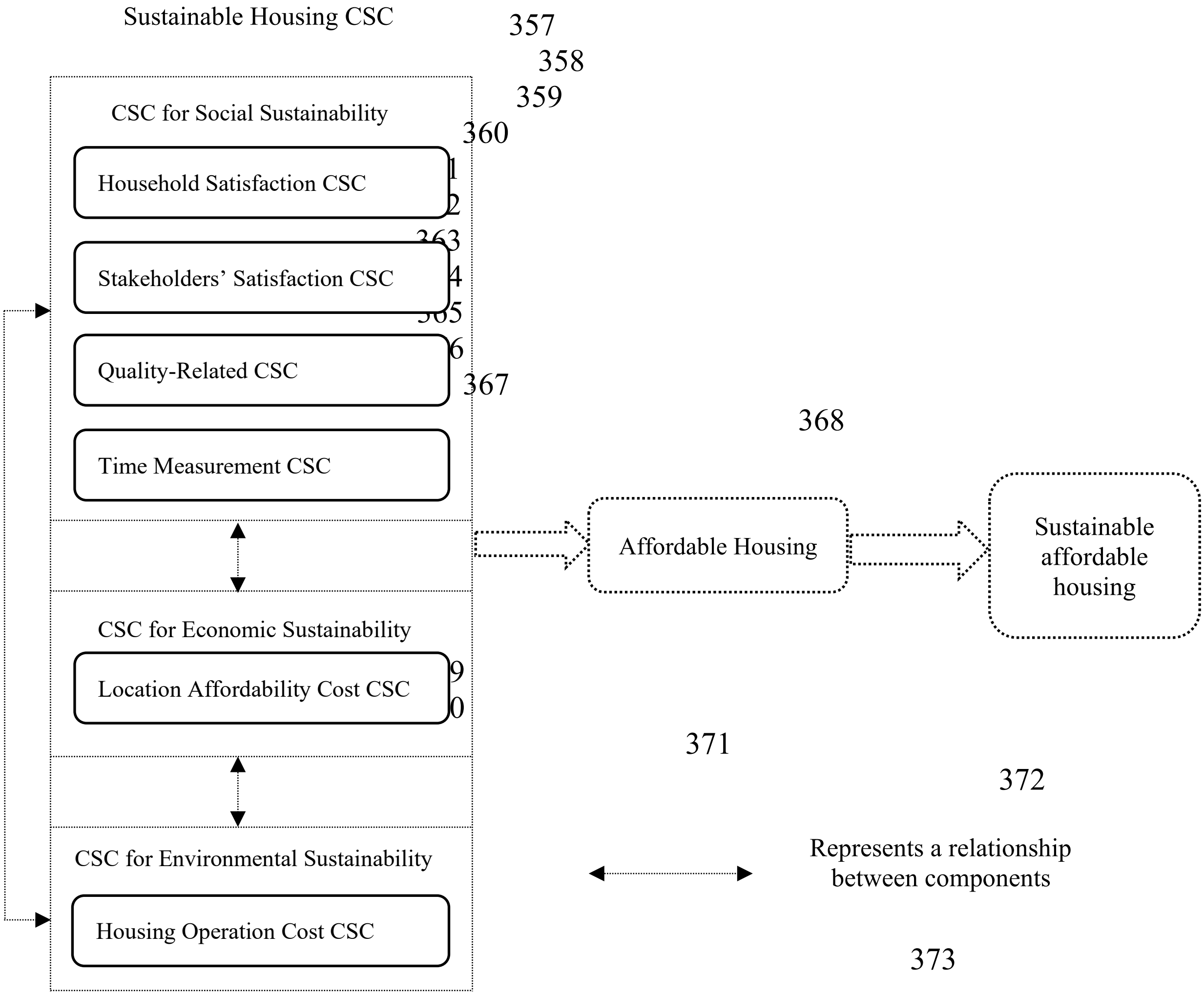

Fig. 2: A Framework for Sustainable Affordable Housing

4.5 Application of the CSC for Sustainable Affordable Housing

CSC serve as a set of standards by which anything is or can be judged (Lim and Mohammed, 1999). The essence of CSC is to develop a set of criteria or standards which serve as guidelines by which policy makers can assess the outcomes of projects (Chan and Chan, 2004). While some of these CSC (such as location affordability cost CSC, housing operation cost CSC and time measure CSC) can be measured objectively through formulae / standard values, the other components of CSC (such as quality-related CSC, household satisfaction CSC and stakeholder's satisfaction CSC) use personal judgement and subjective opinions of stakeholders of affordable housing projects (Chan and Chan, 2004; Adabre and Chan, 2018). Concerning the objective CSC, a standard for location affordability cost can be established by combining housing and transportation costs. It has been estimated that housing is affordable if the combined housing and transportation cost is less than 45% of household income. Using this standard, policy makers could be guided on determining an appropriate location for siting an affordable housing project. Moreover, it could also serve as a guide to household towards identifying the best affordable location when choosing a home (Isalou et al., 2014). However, one disadvantage of the location affordability cost standard is that it does not account for the housing operation cost (utility bills) likely to be incurred by potential households. Therefore, a new standard which is a combination of location affordability cost CSC and housing operation cost CSC could provide more impact on affordable housing policy formulation. However, providing a separate standard for household energy cost, Mattioli et al. (2018) stated that in energy efficient affordable housing, 10% or less of household's income on domestic energy is the required standard. Therefore, the energy efficient standard for households will guide policy makers on the appropriate energy efficient strategies to adopt to reduced high energy cost on household income in addition to mitigating environmental impacts such as greenhouse gas emission. Concerning time measurement CSC, one of its aims is to assess the desirability of a dwelling unit among the target households (Pullen et al., 2010). A high take up rate indicates that the housing facilities are desirable to the target household (Chen et al., 2014). However, low take up rate suggests that some aspects of the housing facilities need to be improved.

Measurement of the subjective CSC – quality-related CSC, household satisfaction CSC and stakeholder's satisfaction CSC – can be conducted by using a Likert scale (Chan and Chan, 2004). For instance, using a five-point Likert scale (1-not satisfied to 5- very satisfied), the satisfaction of households or stakeholders with regard to affordable housing projects could be measured. A low satisfaction score could serve as a guide to policy makers that the housing facility needs to be improved. Besides, reasons for low satisfaction could serve as a guide for the construction of subsequent affordable housing projects.

5. Conclusions

The meaning of success, most often, changes from project to project. Determining whether an affordable housing project is sustainable and therefore a success or a failure is far more complex. This is because there are inadequate studies on identifying a comprehensive list of CSC for assessing the sustainability and success of affordable housing projects. Consequently, affordable housing is mostly assessed based on the price or rental cost, which creates a gap between affordable housing and sustainable housing. Bridging this gap requires sustainable CSC. This study aimed to investigate the CSC required for the provision of sustainable affordable housing. A questionnaire of 21 CSC was administered globally to affordable housing experts. Ranking, factor analysis and Pearson correlation were employed for data analysis.

Findings of this study revealed that though there is high interest on other CSC (such as energy efficiency of housing facility, reduced lifecycle cost of housing facility and environmental performance of housing facility), price and rental cost CSC are the most highly ranked among developed and developing countries. Besides, some of the identified CSC are significantly correlated with one another. Furthermore, six factors were developed for bridging the gap between sustainable housing and affordable housing: (1) household satisfaction CSC, (2) stakeholder's satisfaction CSC, (3) housing operation cost CSC, (4) time measurement CSC, (5) location affordability cost CSC and (6) quality-related CSC.

A limitation of this study is that only the opinions of affordable housing experts were considered. The views of households of affordable housing units were excluded. For further studies, it is would be interesting to analyze the views of households on CSC for sustainable affordable together with the views of academics and contractor. Besides, the sample size used for this study is relative small. Therefore, future study with much larger responses could employ statistical analysis such as ANOVA to compare and determine any statistical differences among the views of the various affordable housing stakeholders.
Though the study has limitations, there are important contributions of the findings of the study worth stating. The findings of the study have contributed to filling the knowledge gap in the affordable housing literature by providing a comprehensive list of CSC for assessing success in sustainable affordable housing. In addition, the identified CSC are evaluation criteria for bridging the gap between sustainable housing and affordable housing. Moreover, real estate developers, architects, international organizations and government agencies could rely on these CSC for resource allocation in the provision of sustainable affordable housing. The identified CSC could be used by policy makers for identifying suitable locations for affordable housing projects. Furthermore, the CSC could be relevant to potential households in identifying the best affordable location and the most energy efficient housing facility when choosing a home. Moreover, by using the identified CSC from this study, policy makers could be informed of the success level of projects and the possible improvement policies to reduce affordable housing overhang. Finally, the time-measurement CSC could be used to measure the distributional outcome of affordable housing for the achievement of social sustainability. One critical policy implication of this study is that due to high cost of implementing sustainable housing strategies to attaining the identified six components of CSC, incentives from the government could motivate real estate developers to include energy efficient strategies and other sustainability strategies in the design and construction of sustainable affordable housing projects.

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