Environmentally Sustainable Affordable Design Elements in Housing in the context of Malaysia: Focus on Middle income group

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Abstract: Sustainability is an integral part of any development in today's world and built-environment is no exception. However, sustainability is not always associated with the issue of affordability. When it comes to housing, where different income groups are involved in large scale, it is utterly significant to consider affordability issues. The objective of this study was to identify environmentally sustainable elements of housing in the context of the hot-humid climate in Malaysia, which can simultaneously be affordable to a significantly rising middle class people in the country. Through a systematic review process the most authentic literatures in the field were reviewed in order to identify environmentally sustainable passive and active elements in the particular context of Malaysia. However, theoretical investigation was non-conclusive to determine affordability of few passive and active elements. A market study, including interviews with contractors was carried out in order to assign the market price of these elements. A 5-point Likert scale questionnaire survey was then conducted on a sample of middle-income groups selected through conditional sampling method. After statistical verification, results showed that several user-controlled passive and active elements were not affordable. The aim of the study was to provide a list of environmentally sustainable and affordable building elements, which could help developers to deliver a better sustainable affordable built environment.

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1. Introduction

Throughout history, human beings have been consumedly using fossil fuels to produce energy. By the time of the industrial revolution, applying fossil fuels for technology had been defined as a sign of progress and advancement in lifestyle (World History, 2013). However, due to exhaustive usage, nowadays mankind is faced with some universal problems such as global warming, air pollution, high carbon emissions, deforestation etc. Therefore, reduction in energy consumption in the sustainable development is a priority all over the world. Sustainability is the minimum condition that the planet needs to continue to maintain its life and systems towards the future.

Hot humid tropical conditions in Malaysia create the high temperature and low air flow which affects the comfort especially in residential buildings. Artificial methods such as the extensive usage of air-conditioning are common in such climate in order to achieve that indoor thermal comfort, but they are not considered as sustainable due to their adverse effect on the environment. Therefore, it is important to understand the solar radiation, temperature and wind profile outside buildings in this context. There are studies which focused on environmentally sustainable elements in hot and humid climate. However, they have not been considered whether such elements are affordable for particular income groups of people. In the context of a big group of middle income people in Malaysia, it is important to study on not only sustainable but also affordable sustainable building elements.

Recently, the Malaysian government concentrated on middle-income people to build more affordable housing for them. There exist some obstacles to housing ownership particularly for middle-income population. However, the government was drawing up strategies to tackle such problem in order to highlight 'people first' concept (Insider, 2012). Besides, affordability may not solve the bigger issue as the bulks of housing have significant impact on the environment. Therefore, there is necessity to search for affordable sustainable elements, which might enable and provide the building designer with a wider range of options in selecting appropriate tropical building design strategy and also achieving the balance between residents' income and ability to buy housing units.

2. Background study

2.1. Systematic review: Choosing the most relevant and updated literature

A systematic review is a kind of literature review concentrated on a research question which applies explicit techniques to identify, evaluate, designate and compound all high-quality research evidence related to such question. Moreover, it

examines data stem from the research to determine which ones can be included in the next studies. Although systematic review is mostly used in the biomedical or health care context, it may also be applied in any field of research (Ader et al., 2008). One of the up-to-date ways to improve the reporting guidelines of systematic review is PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses). PRISMA statement is a new revision of the QUOROM statement (QUality Of Reporting Of Meta-analyses) PRISMA has got three parts; a 27- item checklist, a four-phase flow diagram, an explanation and elaboration document (Moher et al., 2009). PRISMA checklist tests the presence of certain key aspects of the literature, while the flow diagram checks filters down the number of literature to be included in the subsequent research, the explanation and elaboration document provides clear guidance for each of the 27 items. Through this method, an authentic list of literature can be distinguished prior to the detail investigation. The following sections gradually explain the existing literature on the key points of this research after those literatures has been filtered and chosen through systematic review.

2.2. Environmentally Sustainable Design Elements

Housing is a collective expression of houses and inarguably the biggest bulk of built environment. Housing also has significant economic and social impacts; the other pillars of sustainability, environmental sustainability is one major concern as far as the performance of residential buildings are concerned. Though the energy consumptions of residential buildings are different in nature from commercial or industrial buildings, due to its bulk, its impact on the environment cannot be ignored. Throughout the world, residential buildings are involved in huge deal of greenhouse emissions, energy and material use, waste production and change in land-use dynamics (American Essays, 2013). For the rest of the article, sustainability is represented environmental sustainability. People spend a considerable time in their houses. Houses are places where inhabitants seek comfort. The comfort level can be achieved through a surrounding physical environment by the use of different energy sources. As a consequence of the global awareness about energy consciousness, people nowadays are encouraged to use sustainable energy saving features.

2.3. Passive and Active sustainable features

In the recent decades, scientists have been considerably researching renewable energy to design sustainable buildings in order to decrease the negative impacts of the built environment on human health and the natural environment (U.S.E.P Agency, 2009). There are two major types of features to design environmentally sustainable building: passive and active.

Passive design elements are basic for environmental sustainability in building, and are directly related to climatic issues. It maximizes comfort while minimizing energy use and other unpleasant impacts of the environment. In this approach, the building takes advantages of natural sources of energy, such as the sun, wind and rain to provide heating, cooling, ventilation and lighting of living spaces. Passive solar systems have few moving parts, require minimal maintenance, no necessity to mechanical devices such as fans, pumps or electrical controls, reduce greenhouse gas emissions and heating or cooling bills (Reardon, 2010).

Active design elements use external electrical or mechanical equipment to reap, reserve and transform energy (Maier, 2013). For example, there are devices that have been designed to heat a fluid and then pump the hot fluid (air or liquid) via a collector to heat the indoor (U.S.Energy, 2012). Such elements can be used for heating, cooling or for other energy use. For instance, solar water heater and solar photovoltaic panels are used to heat the water and generate electricity respectively by harnessing solar energy of the sun.

In comparison with active elements, passive elements are more sustainable. Since passive energy systems utilize much fewer natural resources in order to construct and maintain, they are also cheaper compared to active ones. Passive systems are less sensitive to malfunction because they depend entirely on nature, instead of applying mechanical tools to generate energy (Desbarats, 1980). A basic difference between them is that passive solar energy uses the sun's heat, but its active counterpart exerts the solar irradiance in order to provide solar electricity to be applied in houses (Dawnallcot, 2011). Generally, an active solar home will cost more because of building a collector area and a heated storage area extra to the house. However, there is practically no point to use a sustainable feature which is expensive, and not affordable by majority users. Thus, the issue of affordability comes immediately to the sustainability issues. Therefore, sustainability is more and more being linked with affordability, and housing is not an exception.

2.4. Sustainable affordable housing

There is a subtle difference between affordable sustainable housing and affordable housing. Affordable housing aims at providing a basic shelter for especially the middle and low income group, and generally described in economic terms (Robert Tanton et al., 2008). It may not automatically ensure environmentally sustainable features there

(Sustainable Cities, 2012). An affordable sustainable housing means not only that the house is affordable, but also there are affordable features that ensure sustainability. In other words, there is a necessity for sustainable solutions in the affordable housing sector, and it is essential that affordability and sustainability issues are tackled simultaneously.

Affordable housing projects, be it public or private, needs to be developed in mass scale. Therefore it can be assumed that only big scale developers can deliver that (Kabir and Bustani, 2009). However, one disadvantage of mass production is that there is a communication gap between the designer and the end user. Incorporating sustainable features are basically at the designer's disposal and these are necessarily passive features. Some of these passive features may have a significant impact on the total cost. Thus, those elements should be checked with potential end-users in order to make them affordable. Those which are widely accepted as affordable can be defined as designer-controlled affordable sustainable features, while some others which are not widely accepted as affordable can be defined as user-controlled affordable sustainable features. However these two lists are dependent on the particular contexts. Moreover, the active features are usually always within the control of the users and they are in the category of user-controlled affordable sustainable features. These are discussed below for the particular context of Malaysian hot-humid climate.

2.4.1. Designer-controlled elements

Designer-controlled elements are those that can be applied during the design process by specialists and architects. In other words, designers are the only ones who are responsible to consider them. Here affordability of target groups is relegated to secondary behind sustainability. However, most of them are usually an integral part of the building design process, and are usually considered to be acceptable and affordable for any income group of users. For example, building orientation is one of these elements that should be considered in the design process by experts who have sufficient knowledge about climatic issues such as sun circulation, wind movement and so on.

2.4.2. User-controlled elements

User-controlled elements can be directly dependent on users' financial power, though knowledge, trend, etc. can also play some role. Users have a say in the decision to or not to include any elements in the design (Khan et. al. 2010). Considering affordability as the determinant, it implies that users would decide whether these elements are affordable for them or not. PV (Photo Voltaic) solar panel is a proper example in this case. Active design elements have been considered in the design process only by user's decision, while passive ones have been related to both designer and user. In this study, several active and passive elements were considered to be relevant in the Malaysian hot-humid climate. From literature, fifteen of them (passive) were found to be acceptable as designer-controlled affordable sustainable element. Four more were found from literature to be relevant in the context, but they were not conclusive regarding the particular income group in the context of Malaysia. Therefore, these four (two passive and two active) elements were considered as user-controlled elements and field study was carried out to determine whether they can be considered as affordable sustainable elements.

2.5. Housing in hot-humid climate

Hot and humid climates present a unique challenge in home building design; the intense sunshine with high temperature brings about a large thermal load on homes resulting in higher cooling costs, makes discomfort and harms home furnishings. Moreover, high humidity and rainfall are important issues because the ambient air has got great levels of moisture most of the year. In order to assist the building industry in those areas, ASHRAE research has recently concentrated on building design in the tropical regions. Malaysia is the context of this study. It is located between 1° N and 7° N of the Equator and also 100° E to 120°E within tropical region which experiences daily diurnal temperature between 24°C and 36°C. The relative humidity in Malaysia is high, ranging from 70% to 90 %. The average rainfall is 250 Centimeters (98 in) a year (Saw, 2007). In this context, overheated outdoor environment causes inconvenience to indoor atmosphere and increases energy consumption especially in the housing sector. Thus, it needs decreasing of indoor daytime temperature below the outdoor temperature by using passive or active design elements. Therefore, it is significant to study what are those elements and how affordable they are.

2.6. Middle-income people in Urban Malaysia

Housing affordability is aimed to ensure the housing provided is affordable by every income earner group whether low-income, middle-income, or high-income. The middle class is a class of people in the middle of the societal hierarchy; this class is the largest community of people in today's society who set among the working class and upper class socio-economic. The general actions what makes middle class differ between nations substantially. According to National Census, every household in Malaysia was categorized based on income levels, location (urban or rural), number of members in the household and other supporting criteria. Thus, middle-income group in Malaysia which has made 40% of the population earn

4,573 Ringgit (RM) per month. (1 USD = 3.1 RM as on June 2013) (Statistics, 2013). Housing ownership particularly for the middle-income group is a problematic issue in Malaysia (Musa et al., 2011). Although a host of guiding policies was held to support the low-income population so that they can afford housing ownership, the ability to own houses among the middle-income group was not given enough attention (Tawil et al., 2011).

3. Method

The PRISMA statement is an intelligent system with 27 items spread along four different levels of filtering. At the end we can find a set of authentic literature. However, in this study all the 27 features have not been investigated for all the literature but the basic ones. From the PRISMA checklist items 9 and 17 (study selection) were considered to select the literature that would be relevant to this study. It modified four phase flow diagram of PRISMA statement and concerned only for Identification and Eligibility (Figure 1).

Figure 1. Data process via the diverse steps of PRISMA

In the Eligibility test, different sustainable building elements were listed. This list was narrowed down to the context of hot-humid housing (19 elements) to find affordability which was the main objective of this research. Literature review did not prove to be adequate because of its context specificity. It was also found that whether these building elements were passive or active, some of them could be designer-controlled, but were proven to be affordable. However, some other which the users have the option to choose from, might or might not be affordable. For that reason the market study was conducted to find the current unit price of these building elements [passive or active]. After that a 5-point Likert scale questionnaire survey was conducted on conditionally selected sample of middle-income group who are associated to be the housing inhabitants in the context of urban Malaysia. After analyzing the data, the number of affordable building elements were further reduced in order to complete the final list (Figure 2, and Table 1).

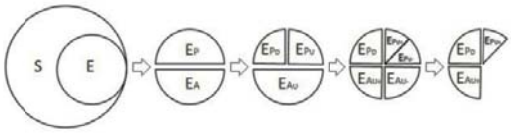

Figure 2. Diagram of methodological framework

Legends:

S= Sustainable design element
E= Sustainable design element for housing in hot-humid climate of Malaysia
EP= Passive design element for housing in hot-humid climate of Malaysia
EP_D= Designer-controlled passive element
EP_U= User-controlled passive element
EP_{U+}= Affordable user-controlled passive element
EP_{U-}= Non-affordable user-controlled passive element
EA= Active design element for housing in hot-humid climate of Malaysia
EA_U= User-controlled active element
EP_{U+}= Affordable user-controlled active element
EA_{U-}= Non-affordable user-controlled active element.

Table 1. Methodological framework of research

Step	Description	
1	Sustainable design elements of housing within hot-humid climate (**E**= 19)	Literatu re
2	**E**= Passive (**EP**= 17) + Active (**EA** = 2) elements	
3	**EP = EP_D** (Designer-controlled, and affordable) + **EP_U** (User-controlled) **EA**= **EA_U** (only user-controlled)	
4	Hypothesis: **EP_U** = **EP_{U+}** (Affordable) + **EP_{U-}** (Not affordable) **EA_U** = **EA_{U+}** (Affordable) + **EA_{U-}**(Not affordable)	Field Study
5	Market study was done on **EA_U** and **EP_U** to find their unit price	
6	Questionnaire survey was done on a sample to identify Affordable(**EP_{U+}** + **EA_{U+}**) and not-affordable (**EP_{U-}** + **EA_{U-}**)	
7	The final list of affordable sustainable elements were derived by statistical analysis	

4. Eligible Design Elements for Sustainable Housing in Hot-humid climate

4.1. Designer-controlled features [EP_D]

1. Building orientation: According to Thomas and Garnham (2007) it is the most significant in creating passive building. Proper orientation enhances the energy efficiency of a house, creating a more convenient place to live and also cheaper to run. Generally, it has been proved that buildings with long directional axis facing

North-South which minimize the East-West exposure have been optimized in case of orientation (Standards Malaysia, 2007) (Figure 3a).

2. Building form: It was claimed that the most cost-effective form of residential blocks in Malaysia with regards to sun path and prevailing wind direction is elongated East-West rectangular with minimum fenestration on both east and west sides (Konya, 1980) (Figure 3a).

3. Building Size: LEED for homes is a green rating system which introduced energy-efficient and healthy housing for residents. It was used to estimate the optimum size of housing units according to their bedroom's number to show whether it is sustainable or not. This code marked from -10 to +10, reveals that in parallel with rising numbers from negative to positive, sustainability points will be increased (Council, 2005).

4. Building density: Davies (2000) wrote that in many urban areas high density buildings can provide an optimum form commonly that magnifies density while minimizing overcrowding, through mixed use.

5. Sun shading device: In tropical hot-humid climate, projected canopy on the east and west as well as protruding fins besides windows on the north and south are the best shading devices (Nielsen, 2007). It was proved that egg-crate shading device (combination of horizontal and vertical fins) due to its function which prevents the sun's rays from different angles, has the most profits compared to other shading types in reducing daily solar heat gain (Al-Tamimi and Fadzil, 2011) (Figure 3b).

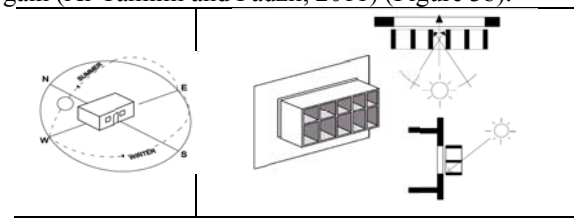

Figure 3. a) Optimum building orientation, b) Egg-crate shading device

6. Natural ventilation: It includes two essential demands in buildings; elimination of impure air and moisture via external air and wind that result in achievement of thermal comfort, energy saving and cost reduction. Besides, it considerably reduce usage of mechanical ventilation and air conditioning (Xu et al., 2006) . In hot-humid climate, natural ventilation in most cases is the best option for low-cost passive cooling techniques, especially night ventilation in summer and full-day ventilation in temperate seasons (Nguyen and Reiter, 2012) (Figure 4a).

7. Natural lighting: Day lighting creates more pleasant and high-quality illumination compared to artificial ones. Moreover, it decreases electrical light use, related costs and pollution. Side lighting is preferred to be used in medium and high-rise housing instead of top lighting. Some elements such as screens, shades and light shelves were suggested to obstruct the direct sunlight that makes ample thermal gains and brightness in tropical climate (Le Thi Hong Na and Jin-Ho Park, 2009) (Figure 4b).

8. Thermal mass: It has been claimed that in hot-humid climate, high thermal mass materials as brick and concrete block with adequate thickness can be selected for housing to diminish and postpone the negative impacts on internal spaces via external wall temperature fluctuation (Xu et al., 2006).

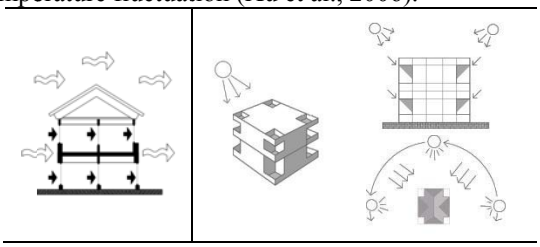

Figure 4. a) Natural ventilation, b) Natural lighting

9. Insulation: It has been proved that by applying light color, shading devices on the building's facade and also well ventilation especially in attics, there is no insulation needed in hot humid climate (Figure 5a). In order to use insulation, polystyrene is the most common insulation at an affordable price in hot humid climate (Garde et al., 2001).

10. Landscaping: The aim of landscaping as a passive element is to moderate air temperature, humidity and radiation in a special location. A well-designed landscape involving both soft and hard landscape elements contribute to control microclimate and also to decrease the amount of heat gain in the house (Parker, 1981) (Figure 5b).

11. Building openings: Building's façade should have adaptable openings which act as sieve-like filters with different segments causing natural ventilation, creating outer visions, adjusting cross ventilation, protecting from harmful sun lights and so on. In Malaysia window opening is better being large enough to receive breeze stem from local prevailing wind (Konya, 1980) (Figure 5c).

Figure 5. a) Using attics instead of roof insulation, b) Using landscape to moderate air temperature, c) Bigger openings are necessary for cross ventilation

12. Courtyard: It was detected to be energy efficient in all, particularly in hot humid climates. Its form in terms of natural lighting and ventilation in low and mid-rise building is more compatible in comparison with high-rise ones for which atrium are more appropriate. It has been argued that deep and elongated courtyard's geometry receives maximum internal shading area in the summer that resulting in low energy consumption (Al-Masri and Abu-Hijleh, 2012).

13. Balcony: Despite of an aesthetic issue, balcony has got some functional advantages like reducing energy use, operating as an overhang for underneath the window and avoiding overheating inside of residential flats by preventing from obstruction for cross ventilation (Knudstrup et al., 2009) (Figure. 6a).

14. Solar chimney: It has been proved that for area with high solar radiation and low wind speed like Malaysia, solar chimney is an adaptable, profitable and affordable design element. Besides, it can be applied as an alternative for air conditioning systems to retrench trapped heat in the house continuously (Zhai et al., 2011). However, ventilation wells can also be used to get rid of the hot air (Figure. 6b).

15. Raised floor: In Malaysia which is defined by heavy, tropical rain, the raised floor is a key factor and quick remedy. The conventional raised floor not only lets air flow go around building easily, but also hinders ground's humidity to attain house's floor. Moreover, the area beneath the house is secure for children to play and suitable place for other social activities during the day (Tahir et al., 2010) (Figure 6c).

Figure 6. a) Balcony with its aesthetical and functional aspects, b) Ventilation shafts as an alternative to solar chimney, c) Raised floor solves multiple climatic issues such as air-flow and humidity.

4.2. User-controlled features [EP_U + EA_U]

Through interviewing with construction managers and contractors, most of them were of the same opinion that application of some new and green elements in building sector could be good alternatives than the conventional ones as energy consumption would be substantially decreased. These four elements were 'building material' and 'building structure' as passive elements, and 'solar water heater' and 'PV solar panel' as active ones.

1. Building material: AAC (Autoclaved Aerated Concrete) block is a suitable alternative to Cement Sand Brick which nowadays is a common material used widely in Malaysia. AAC block which is composed of sand, water, cement, gypsum and quick lime has numerous privileges in comparison with other building materials, such as environment protection, energy saving, excellent acoustic performance, fire resistant, non-toxic, light weight, long life and rapid on-site assembly.

2. Building structure: IBS (Industrialized Building System) is an efficient building structure with a number of benefits that can be a deserving alternative to the conventional building structure. IBS usage is still not widespread in the industry. The main reasons for the low adoption of IBS in Malaysia are lack of integration at the design stage and poor knowledge about IBS. Its advantages include reducing wastage, the site materials, costs and labor at site; enhancing efficiency, having faster completion and flexible design.

3. PV solar panel: One of the solar energy applications which is widely used in harnessing solar energy is solar photovoltaic (PV), through which the sunlight is converted into electricity. Solar energy has been certified such a limitless as well as a free energy source that can supply an alternative energy with lack of environment pollution. Its usage will reduce the depletion rate of energy reserves (Sharan, 2009). Mono-crystalline, poly-crystalline and amorphous are the types of PV panels that are usually used in Malaysia with various efficiencies. The performance ratio of each type shows that poly-crystalline solar module is the most appropriate kind of PV in terms of lower cost among all to be applied in hot-humid climate of Malaysia.

4. Solar water heater: Solar heating system utilizes solar concentrators to convert sunlight to heat, which becomes the source of water heating system. It is one of the simplest and economical ways to utilize solar energy. Malaysia has got a favorable climate for Solar Water Heaters (SWHs) in commercial as well as household demands. Owing to SWHs primary high price and also the lack of public knowledge, Electric Water Heaters (EWHs) are more popular among Malaysian families because of easy installation and low price.

5. Result and discussion

5.1. Finding a list of eligible literature

A careful literature review has provided the details of all common sustainable elements for hot-humid climate in the building. But, as mentioned in the method section, not enough information was found from the literature on their affordability in the particular context of Malaysia. For the study selection

the Identification criteria were 'sustainable housing' (209 studies were found in this case). Besides, the Eligibility criteria were 'environmentally sustainable housing' (78 studies were found in this case). In this phase the other pillars of sustainability (economic and social) have been removed from the list.

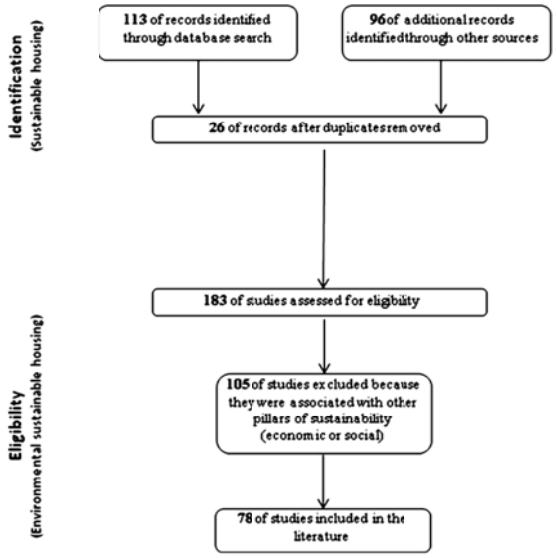

Figure 7. The flow diagram of literature based on PRISMA

5.2. Finding of market study

Four sustainable user-controlled elements were introduced in the previous section. In this part, the amounts of money that should be paid by occupants per month for these items have been calculated via some equations. The data which support these equations were acquired from Department of Statistics Malaysia.

According to the cost of per AAC BLOCK in comparison to the cost of cement sand brick which is a common building material has been used in Malaysia, residents should pay extra RM 7440.00 money if they wanted to live in housing units which were made by AAC blocks. Thus, if they are given a ten-year period of time to pay it, then they should pay extra **RM 62.00** per month for ten years. Moreover, they should pay extra RM 13440.00 money if they want to live in housing units constructed by IBS compared to conventional building system. Thus, if they are given approximately a twenty-year period of time to pay it, then they should pay extra **RM 59.00** per month for twenty years. Likewise, if respondents wanted to use poly-crystalline solar panel, they should pay RM 247,268.00 more than the payment that they were making for the conventional system nowadays. Therefore, if they were given approximately a twenty-year period of time to pay it, then they should pay extra **RM 1000** monthly for twenty years. Finally occupants should pay extra **RM 33** per month, in a ten-year period of time to apply solar water heater instead of electric water heater in their housing unit.

5.3. Questionnaire survey

After the market study found the current unit price of sustainable building elements [passive and active], a 5-point Likert scale questionnaire survey was conducted on conditionally selected sample of middle-income group in the context of urban Malaysia. The questions in this survey were divided into three parts. First part was devoted to general issues and demographic questions such as gender, age, marital status, education level and occupation. Second part was related to housing issues that included questions about household income, type of housing and the amount of money that respondents are willing to pay for their housing units. The third part included the most important questions concerning sustainability and affordability issues. These questions demonstrated; awareness level of respondents about environmentally-friendly energy, their tendency to live in the sustainable housing, and measuring the agreement rate of participant to pay for sustainable elements in the housing sector such as solar water heater, PV solar panel, sustainable building material and structure. Participants' affordability to pay for sustainable housing was the last question in such survey. A questionnaire survey was distributed among one hundred respondents in Johor Bahru, who were mainly categorized in the middle-income group. SPSS software was used to analyze the data in this study.

5.4. Analysis of questionnaire

For examining the determinants of housing affordability, a series of statistical techniques were conducted. Firstly, reliability analysis through Cronbach's alpha was applied in the research. This figure, which is the most popular method of examining reliability was 0.739. As it was placed between 0.7 and 0.8, it showed the result was acceptable. Secondly, the KMO (Kaiser-Meyer-Olkin) measure and Bartlett's test was applied to identify the sample adequacy. The KMO value was 0.686 that is greater than 0.5 to have a satisfactory value to proceed to factor analysis. Finally, exploratory factor analysis and correlation analysis were conducted to find various relationships.

Figure 8 shows the dependent and independent variables in the survey. According to this conceptual framework, three independent variables of demographics, housing and affordability features (Likert scale) were developed with each consisting of several item variables. Knowledge and wllingness of respondents were extra item variables under affordability features trying to find a relationship with affordability.

Table 2. Summary of the demographics, housing and affordability variables

Variables	Descriptives	Mean
Gender	**1** if you are male; **2** female	1.60
Age	**1** if your age is <20 ; 20<**2**<30; 30<**3**<40; **4**>40	2.98
Marital Status	**1** if you are single; **2** married; **3** divorced; **4** widow	1.88
Education	**1** less than high school; **2** high school degree or equivalent; **3** some college but no degree; **4** associate degree; **5** bachelor degree; **6** master degree or more	2.85
Occupation	**1** government employee; **2** retired; **3** others	1.12
Income	**1** if your household income is < RM 4000; RM 4000<**2**<RM 9000; **3**> RM 9000	1.68
Housing Type	**1** if you live in bungalow; **2** terraced house; **3** flats; **4** others	2.32
Housing Ownership	**1** if you are owner; **2** tenant	1.20
Housing Expenses	**1** if you pay for your housing services less than RM100; RM100<**2**<RM500; RM500<**3**<RM1000; **4**>RM1000	2.42
Familiarity about Sustainability	**1** strongly disagree; **2** disagree; **3** neutral; **4** agree; **5** strongly agree	2.70
Willingness for Sustainability	**1** strongly disagree; **2** disagree; **3** neutral; **4** agree; **5** strongly agree	3.72
Solar Water Heater	Willing to pay RM33 monthly until 10 years;**1** strongly disagree; **2** disagree; **3** neutral; **4** agree; 5 strongly agree	3.82
Building Material	Willing to pay RM62 monthly until 10 years;**1** strongly disagree; **2** disagree; **3** neutral; **4** agree; **5** strongly agree	2.72
Building Structure	Willing to pay RM59 monthly until 20 years;**1** strongly disagree; **2** disagree; **3** neutral; **4** agree; **5** strongly agree	2.80
PV Solar Panel	Willing to pay RM1000 monthly until 20 years;**1** strongly disagree; **2** disagree; **3** neutral; **4** agree; **5** strongly agree	1.70
Affordability	**1** if you can afford to pay less than RM50 for sustainable housing; RM50<**2**<RM100; RM100<**3**<RM200; **4**>RM200	1.40

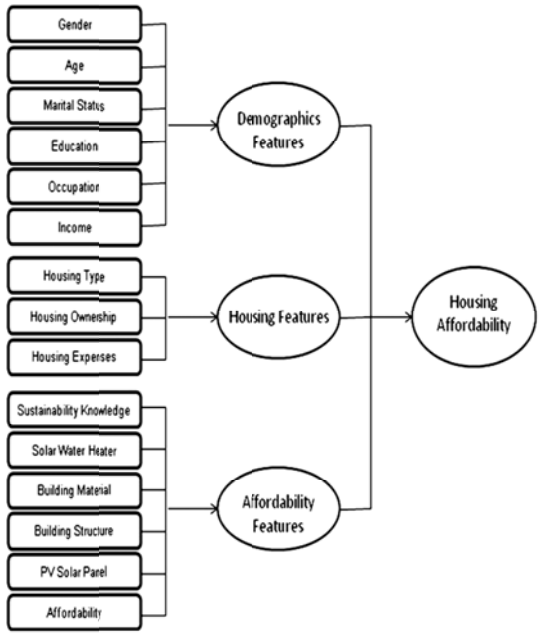

Figure 8. Conceptual framework

Table 2 showed the descriptive analysis of the collected data.

5.4.1. Exploratory factor analysis

In the first phase, principal component analysis with Varimax rotation was performed to examine whether variables related to sustainable design elements can be grouped into a smaller number of factors. Item variables with factor loading less than 0.40 were deleted from the set. 6 questionnaire items was sorted into 2 factors. Factor 1 had four items (sustainable design elements), all the reliability values were above the 0.6 indicating sufficient reliability. However, factor 2 had two items regarding knowledge about sustainability. The composite index was produced from the first two variables (familiarity and willing). The reliability values were ranging from 0.536 to 0.963 (Table 3).

Table 3. Exploratory factor analysis

	Component	
	1	2
Familiarity		.536
Willing		.892
Solar Water Heater	.784	
Building Material	.906	
Building Structure	.848	
PV Solar Panel	.657	

5.4.2. Correlation analysis of affordability price & knowledge

Correlation analysis was performed to examine the strength of association between price of user-controlled sustainable design elements, knowledge and willingness about sustainability, and housing affordability. Table 4 presented the correlation matrix of such items. It appeared that all sustainable design elements were significantly and positively correlated to housing affordability at the significance level of 0.01, except solar water heater which was correlated to affordability at the 0.05 level. However, willingness was not correlated with affordability.

Table 4. Correlations

	Familiarity	Willingness	Solar Water Heater	Building Material	Building Structure	PV Solar Panel	Affordability
Familiarity	1						.464**
Willingness	.127	1					-.022
Solar Water Heater			1				.332*
Building Material			.662**	1			.551**
Building Structure			.625**	.725**	1		.440**
PV Solar Panel			.332*	.439**	.496**	1	.465**
Affordability			.332*	.551**	.440**	.465**	1

* Correlation significant at α = 0.05 (2-tailed)
** Correlation significant at α = 0.01 (2-tailed)

5.4.3. Demographic Features

While the number of females was more than males, men had a little more willingness to pay for sustainable elements. The knowledge and familiarity with sustainability for both groups were the same as each other. The mean score of both showed college education without a degree, and both earned between 4000 and 9000 Ringgit. The mean age for both groups was between 31 and 40. Besides, as level of income increased the education level also increased, and people showed more willingness to live in sustainable housing. Finally, among respondents' another demographic characteristic, household education on sustainability demonstrated significant effect on housing affordability. However, the study revealed that age and income were not significant determinants of housing affordability, and also housing affordability was much higher among home owners in comparison with renters.

5.4.4. Affordability Features

According to descriptive statistics, solar water heater had the highest mean score than the other three elements (3.82). It was concluded that the number was extremely close to 'Agree', so this active element was affordable for the participants to be applied in their housing units. While, for building structure and material the number was 2.80 and 2.72 respectively. Although this figure was between 'Disagree' and 'Neutral', participants were more partial to have neutral opinions rather than disagreeing. Perhaps Lack of knowledge about sustainable issues was a strong reason that made participants to choose neutral opinion about these elements. Besides, PV solar panel got the lowest mean score of 1.70 among all. This figure was between 'Strongly disagree' and 'Disagree', and it was concluded that people who took part in this survey were severely dissatisfied to pay such amount of money for solar electricity in their housing units because of its high price.

6. Conclusions and Recommendations

Figure 9 illustrated the calculation which showed how sixteen sustainable affordable elements (S) for housing in the context of Malaysia were derived from possible nineteen sustainable elements (E). According to the findings, fifteen sustainable elements (EP_D) were defined as design-controlled elements that could be applied in housing units in terms of affordability by architects. Besides, four items ($EP_U + EA_U$) that included two passive and two active elements were examined by interview and questionnaire to check their affordability. Results showed that in the category of active elements, only solar water heater was acceptable for middle-income group in Malaysia to be applied in their housing units, while PV solar panel due to its high price was not appreciated by respondents. In the category of passive elements, both building material and structure were not conclusive and respondents had neutral opinions about them due to their lack of knowledge about sustainability issues.

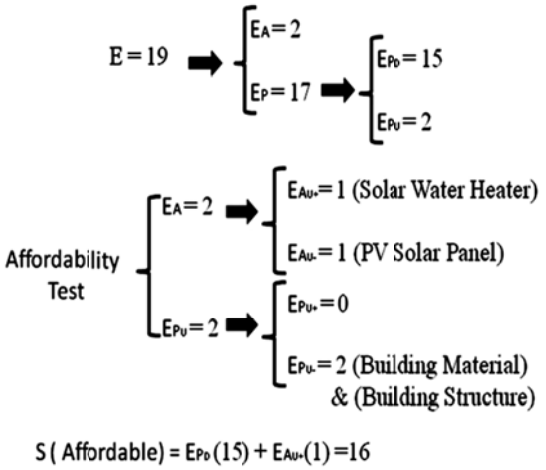

Figure 9. Calculation of sustainable affordable elements applicable to housing in the context of Malaysia

Based on the results, people seemed to be satisfied to pay only for solar water heater which would cost them RM 33 per month. On another note, most of the participants could afford to pay less than RM 50 for environmentally sustainable housing units, and were willing to pay for not more than ten years. From these two points it was obvious why they agreed to pay only for the solar water heater.

It was recommended that the government should take serious measures to pay more attention to middle-income people in Malaysia. For instance, preparing special subsidies for their housing units and also giving them long-term housing loans could be few of the solutions. This could enable them to afford their housing units that offer optimum qualities of life-style as well as environmental sustainability. Besides, the government could devote subsidies for other apparently non-affordable sustainable building elements such as building materials, building structure and also PV solar panels to create green electricity in order to reduce consumption of fossil fuels. On the other hand, as the major problem in the implementation of sustainable construction is lack of awareness and limited knowledge about its benefits, people should be sufficiently educated about the advantages of solar energy and sustainability issues. For example, they can be familiar with sustainability issues via public media such as television, internet or newspapers. It can eventually help them to appreciate sustainable housing, and improve their willingness. Future studies should entail a detailed research regarding how the active elements such as PV solar panels that provide solar electricity can be used in housing units in an economical way for residents and also how the cost of these panels can be decreased compared to their current prices. Moreover, future studies should also reveal how people can be educated about sustainable energy in shorter periods of time.

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