

# Indicators of Sustainable Housing Development (SHD): A Review and Conceptual Framework

Ng Ming Yip, Jamilah Mohamad and Goh Hong Ching

**Abstract**— A conceptual framework that incorporates all relevant indicators of sustainable housing development (SHD) had been developed through literature reviews of related previous studies. The focus of the review is to gather indicators of sustainability used by previous researchers in studying sustainability, particularly in the housing development. It was found that many previous studies focused only on one or two specific dimensions of sustainability. This can affect the overall assessment of housing sustainability and actual sustainable outcomes. The reviewed indicators and conceptual framework can be employed in assessing housing development comprehensively.

**Index Terms**— housing development, indicators, housing sustainability

## 1 INTRODUCTION

Sustainable development remains as a relevant organizing principle in this era. It has been used and further strengthened in various fields such as politics, architecture, technology and transportation. Sustainable development helps us to reflect our role within the ecosystem, implies the effects of human activity towards environment, and provides us a chance to see the world from a new perspective (Hardi and Zdan 1997). In this globalisation and development-oriented era, sustainable development has become a useful concept to the industrialised developed countries that are concerned on the deterioration of environment and natural resources. They believe that environmental degradation must be tackled in a more integrated and holistic way by addressing issues or problems faced within the ecosystem. Developing countries with limited resources tend to view sustainable development concept differently than developed countries where efforts to optimize the use of limited resources to maximize the impact has been the main agenda. However, the ultimate goal of sustainable development can only be achieved throughout the decision-making process that integrates and acknowledges the economic, environmental and social concerns (Rachel 2015). Expressly stated, sustainable development can be translated into a useful strategy that can solve specific problems or minimize the

negative impact brought upon by a specific social, economic and environmental issue faced by people across the world.

House is one of the basic necessities that is closest to human life. House and its surroundings will affect human directly. Therefore, sustainable development is unachievable without sustainable building and housing (Abu Hassan and Abu Bakar 2011). Government development program always place housing development as an integral aspect in that process. It overlaps with health, education, employment, culture, crime, and many other aspects of life. Housing development is now more focused on houses that are able to meet the social, environmental and economic needs of people. Therefore, developers put in effort to build houses that are more affordable, high-tech, environmentally friendly and energy efficient. All these elements are important factors that could affect the overall performance of housing development. Based on the essence of sustainable development, sustainable housing development (SHD) aims to ensure a better quality of life for present and future generations. It should combine and positively integrate physical, social, environmental, and economic dimension of sustainability. Therefore, SHD is seen as a practical approach that can help to address housing issues that exist consistently and ensure residents are comfortable with the housing development.

SHD is influenced by factors that account for physical, social, environmental and economic dimensions (Figure 1) like location factors, cultural factors, waste management factors and energy consumption factors, respectively. These factors are indicators used to reflect the

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level of housing sustainability. Sustainability indicators and assessment can be powerful decision-supporting tools in fostering sustainable development through addressing three sustainability decision-making challenges (Waas et al. 2014). Sustainability indicators should contain a number of important characteristics: (a) integrating sustainability indicators to describe the relationship between economic, environmental and social dimensions of sustainability; (b) forward-looking using two types of forward-looking methods. For example, a trend indicator describes historical trends and provides indirect information about future sustainability. Whereas, a predictive indicator rely on mathematical models for the future development of variables describing the environment, economy, and society, or the linkages among them; (c) distributional in nature, as they should be able to consider the distribution of conditions (social, economic, environmental) within a population or across geographic regions; (d) uses multi-stakeholder input, as the most significant, valid and reliable social indicators have been those developed from a wide range of participants (Maclaren, 1996).

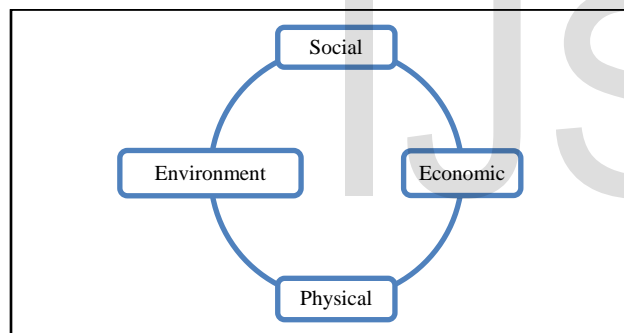


Fig. 1. Dimensions of sustainable housing development.

Various approaches through a conceptual framework or model have been developed by previous researchers to assess the sustainability of housing development. It measures in a different context and serves different purposes like sustainability for affordable housing (Mulliner, Smallbone and Maliene, 2013; Mulliner and Maliene, 2011), public housing program (Eziyi and Dominic, 2011), low carbon houses (Gupta and Chandiwala, 2008). In most cases, the emphasis is on determining appropriate assessments for specific tasks and organise them in a purposeful way. For example, Mickaityte, Zavadskas and Kaklauskas (2008), developed a conceptual model of sustainable buildings refurbishment and a rating index for the built environment in tropical climates based on the study by Abdouramane et al. (n.d.). Hardi and Zdan (1997) clarified that an effective framework accomplishes two important goals: to determine priorities

in the choice of indicators; and to trigger the identification of indicators that may be more important in the future. Sustainability indicators are integrating in the sense that they attempt to portray linkages among the economic, environmental, and social dimensions of sustainability (Maclaren, 1996).

This paper attempts to review previous studies on SHD. The focus of the review was to identify the characteristics, trends, indicators or parameters used by previous researchers in assessing the development of sustainable housing. Next, the review results will be analysed and used as an input in the SHD conceptual framework building. This paper ends with conclusions and recommendations for future research.

## 2 SUSTAINABLE HOUSING DEVELOPMENT

In Malaysia, the concept of sustainable housing is still new to the public (Hassan, Khor and Rahmawaty, 2011). Jason (as quoted in Hassan et al.) highlighted three main problems that exist in houses built in the past decade. First, energy efficiency and green affordable housing did not take building design into account. Second, sustainability of housing development mostly focuses on environmental, economic and social issues. Third, covers groups of buildings in the housing development affect environmental performance. According to Hassan, Khor, and Rahmawaty (2011), sustainable housing development should use sustainability criteria to measure developed area, especially in terms of environmental, social, economics, site/ land uses, transportation and communication. It should also include the building assessment forms for the purpose of assessing housing performance. The sustainability criteria comprised multiple variables and can be further categorized into six categories, namely, environment, social, economics, building forms, site or land uses, and communication and transportation.

Abdouramane, Nowbuth, Umrikar, and Bhavana (n.d.) believe that sustainable development in built environment plays an important part in establishing comfort within the living environment. Buildings involve large amount of land, water and energy consumption, and changes the air atmosphere. Green building practices are targeted to reduce the environmental impact of new buildings. The combination of environmental, economic and social sustainability is usually defined as sustainability. In general, site planning, energy efficiency, indoor environment quality, water efficiency and material usage were considered in the assessment of green buildings.

Previous and current sustainable-labelled housing projects often consider only certain dimensions of

sustainability such as technical and economic dimensions but neglect social dimension. Therefore, the projects will not ensure sustainable outcomes. According to Huong and Soebarto (2003), the environmental, social, cultural and economic dimensions of sustainability must be taken into account in order to achieve a sustainable housing. Perceptions about sustainable housing contain harmony with the environment, environment protection, and infrastructure (environment dimension). Sustainable housing also promote energy saving and it is long-term/flexible/ durable (environment and economic dimension). Resource conservation, affordability, business opportunity, and fulfilment all economic requirements is an important issue under the economic dimension of sustainable housing. Under social dimension, sustainable housing should be attractive or beautiful, have good design, be convenience for user, and fulfil all social requirements, ownership/administration, type of house, relationship with neighbour, appliances, and feng sui application. In addition to that, location of house is also considered as an important environmental and social issue for sustainable housing in Adelaide and Hanoi.

Sustainable housing development is no stranger from the economic, environmental, and social issues that can affect the performance of sustainable buildings. Challenges in economic sustainability are maintenance of high and stable level of growth and employment, improved project delivery, and increased profitability and productivity. Issues of sustainable building from the environmental aspect emphasis the proper protection of environment by avoiding pollution, protecting and enhancing biodiversity, and green transport planning. Besides that, energy conservation, improved energy efficiency, and efficient use of resources are also the challenges inherent in the buildings sustainable development. Social sustainability for sustainable buildings relates to issues in social progress which recognizes the need of everyone. Respect for staff, working with local communities and road users, and partnership working are principal issues for social sustainability (Akadiri, Chinyio, and Olomolaiye, 2012).

Narydas (2011) defines the principles of sustainable construction through three main aspects of sustainable development, which was introduced by the United Nations. Sustainable construction is a 'rational use of resources, usage of ecological materials, creating healthy and safe environment, social cohesion and social justice, quality of life, cultural diversity, economic welfare and etc' (Figure 2). Planning stage is the most important part of residential construction in which the level of sustainability

is determined (Narydas, 2014). Level of sustainability during the planning stage can be determined by identifying specific requirement of the projects whereby the whole expression of exact building is created. Narydas (2014) identified several major trends of sustainable house. The six trends had been used by the author to develop a model of evaluation of sustainable residential architecture. Social trend of sustainable houses is an affordable and low-cost housing. Ecological trend of sustainable house used environmentally friendly, recycled or easily recyclable materials. Technological trend is characterized by the usage of newest technologies in order to reach maximum energy efficiency. Construction cost saving and minimalistic aesthetics characterize the economic trend of sustainable houses. Aesthetic trend describes expressive design and elaborate composition of colours and volumes. Organic materials are also used in sustainable houses such as plastic forms, technological advancements, and exceptional high quality architecture.

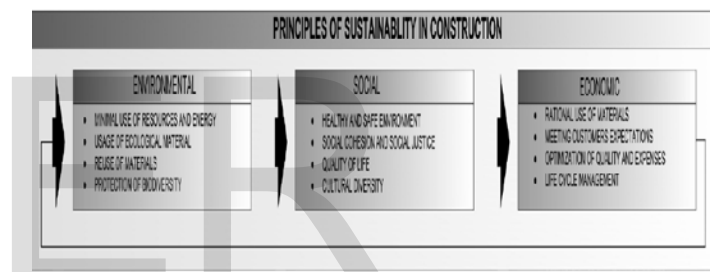


Fig. 2. Relationship between different principles of sustainability in construction (Narydas 2014, 34).

In the research article by Yu and Kim (2011), a green building should contain some of the following characteristics related to land used, site locations, materials used, energy efficiency, water efficiency, surface water management, pollution, and health and wellbeing of occupants. A green building include effective use of existing landscapes, site use, community development and transportation requirement, efficient use of energy and eco-friendly equipment, use of environmental or recycled building materials, promote indoor air quality for human safety and comfort, water efficiency, use of non-toxic materials, use of renewable energy, effective building control and management system, and preservation of ecosystem.

Turcotte and Geiser (2010), in his study on the development of sustainable housing have developed a multidimensional framework which incorporates 10 principles of sustainable housing development. Principles developed based on the results of interviews with 15 key housing informants (e.g. community and housing

development professionals, construction trade union officials, planners, and researchers). The framework has been tested to see how well it might be applied as a guideline for development and a tool for understanding and evaluating actual housing development projects. Those principles are further divided to different sustainable housing development aspects. Green design that emphasizes the use of resources and materials that can minimize the impact on environment is incorporated. It also saves internal space, creates comfortable temperature, physically safe and healthy environment, and promotes overall psychological well-being. Sustainable houses are also affordable and equally distributed. Social aspects of sustainable housing development also contain principles such as promoting occupant-neighbourhood linkage, maximizing access to healthy environments and support services, fostering harmonious participation and decision-making, and preserving cultural heritage and housing. The principles of economic aspect should support the financial viability for housing producers, support worker well-being, and increase adaptability and flexibility of the house.

Each housing program has its own unique characteristics. However, they all could help people to achieve the ideals of sustainable housing. Ibem and Azuh (2011) explained that a framework for assessing the sustainability of public housing programmes should be multidisciplinary and also able to raise specific issues related to the long term social, economic, environmental, technological and cultural consequences of such programmes (Figure 3). Each issues related to housing development will be gathered through different dimensions of sustainability which can be measured by specific parameters developed.

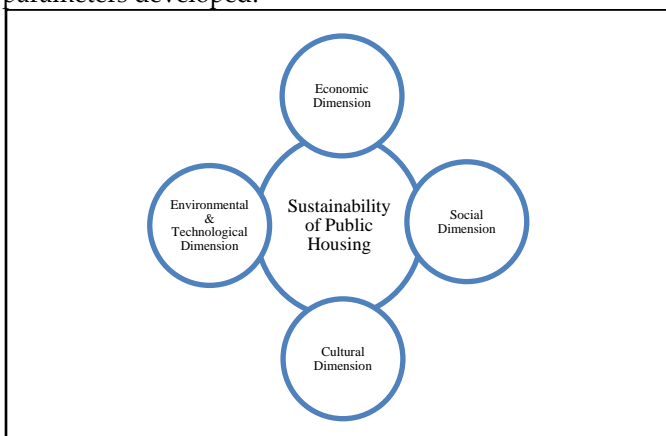


Fig. 3. Parameters for evaluating the sustainability of public housing programmes (Adapted from Ibem and Azuh, 2011).

Pullen, et al. (2010) in their research article presented an assessment framework for affordable and sustainable housing in Australia. The study proposed ten characteristics of affordable and sustainable housing that sought to reflect literature on affordability, economic sustainability, social sustainability, and environmental sustainability. It was found that those indicators dealing with environmental sustainability are reasonably well defined (i.e. energy, materials, water, and methods). Whereas, social sustainability requires further definition and the need to render the measuring indicators useful when assessing affordable and sustainable housing.

Developing and using a clear conceptual framework is very important in the assessment process. It offers a great opportunity to highlight housing related problems that exist. The problems described in the assessment phase will allow several alternative solutions to be proposed. Therefore, SHD conceptual framework allows the comprehensive assessment of housing development through different dimensions of sustainability. The conceptual framework is very important as a prerequisite for understanding the housing situation and its related environment systematically.

### 3 CONCEPTUAL FRAMEWORK OF SHD

The study of literature is the most important step in this review and conceptual building process. This section attempts to lists the indicators that have been used by previous researchers in assessing the sustainability of a sustainable building and housing related program. Indicators of sustainability has been developed by previous researchers based on different study objectives within certain study areas, as listed in Table 1. From the literature review, the framework or model of SHD presented is based on different research objectives and considers certain dimensions of sustainability.

TABLE 1  
REVIEW ON SUSTAINABILITY INDICATORS OF HOUSING DEVELOPMENT.

Authors	Presented Indicators for Sustainable Building
Turcotte and Geiser (2010)	<p>Authors developed a multidimensional framework of sustainable housing development. The framework includes the following 10 principles:</p> <ul style="list-style-type: none"> <li>○ Incorporate green design</li> <li>○ Provide safe internal condition</li> <li>○ Encourage affordable and equitable distribution/ consumption of housing resources</li> <li>○ Support financial viability for</li> </ul>

	<ul style="list-style-type: none"> <li>○ housing producers</li> <li>○ Promote occupant-neighbourhood linkage</li> <li>○ Maximize access to healthy environment and support services</li> <li>○ Support worker well-being</li> <li>○ Preserve cultural and housing heritage</li> <li>○ Foster participation and harmonious decision-making</li> <li>○ Increase adaptability and flexibility</li> </ul>	Winston (2008)	<p>Analytical framework for conceptualising and assessing sustainable housing:</p> <ul style="list-style-type: none"> <li>○ Location: <ul style="list-style-type: none"> <li>- Sustainable land-use planning (resisting scattered settlements)</li> </ul> </li> <li>○ Construction and design: <ul style="list-style-type: none"> <li>- Higher residential densities sustainable construction (e.g. energy efficiency, local renewable materials); Design for sustainable use (e.g. energy use, water recycling &amp; treatment, waste recycling), etc.</li> </ul> </li> <li>○ Use: <ul style="list-style-type: none"> <li>- High standards of energy efficiency in use of dwellings; Waste recycling, etc.</li> </ul> </li> <li>○ Regeneration: <ul style="list-style-type: none"> <li>- All of the above &amp; emphasis on renovation rather than demolition; and Partnership with residents social supports for vulnerable households.</li> </ul> </li> </ul>
Abu Hassan, Khor and Rahmawaty (2011)	<p>Authors developed a framework for a rating system. The framework addressed as Comprehensive Assessment System for Sustainable Housing (CASSH). CASSH serves as an assessment model for housing sustainability. Sustainability criteria and its indicators that contain in the CASSH:</p> <ul style="list-style-type: none"> <li>○ Environmental: <ul style="list-style-type: none"> <li>- Energy, Water, Materials/ Resources, Pollution matters, etc.</li> </ul> </li> <li>○ Social: <ul style="list-style-type: none"> <li>- Community/ Neighbourhoods, Health/ Wellbeing, Security/ Safety, etc.</li> </ul> </li> <li>○ Economics: <ul style="list-style-type: none"> <li>- Market social</li> </ul> </li> <li>○ Building forms <ul style="list-style-type: none"> <li>- Eco, Construction, Indoor, Environments, Design, History, etc.</li> <li>- Landscape, Soil, and Preservation.</li> </ul> </li> <li>○ Communication &amp; Transportation <ul style="list-style-type: none"> <li>- Transportation accessibility &amp; networking, Internet networking &amp; telecommunication, etc.</li> </ul> </li> </ul>	Mulliner, Smallbone and Maliene (2013)	<p>Decision matrix for sustainable housing affordability:</p> <ul style="list-style-type: none"> <li>○ Safety (crime)</li> <li>○ Access to employment</li> <li>○ Access to public transport services</li> <li>○ Access to good quality schools</li> <li>○ Access to shops</li> <li>○ Access to health services</li> <li>○ Access to child care</li> <li>○ Access to leisure</li> <li>○ Access to open green public space</li> <li>○ Quality of housing in area</li> <li>○ Energy efficiency</li> <li>○ Waste management</li> <li>○ Desirability of neighbourhood area</li> <li>○ Deprivation in area</li> <li>○ Presence of environmental problems</li> </ul>
Abdouramane, Nowbuth, Devi and Umrikar (n.d.)	<p>Five category for sustainable building:</p> <ul style="list-style-type: none"> <li>○ Site planning and location</li> <li>○ Energy efficiency</li> <li>○ Indoor air quality</li> <li>○ Water efficiency</li> <li>○ Material usage</li> </ul>		
Hamizah, Fatimah and Hazlina (2012)	<p>Theoretical framework integrating land use planning regulation and sustainability elements in urban housing development:</p> <ul style="list-style-type: none"> <li>○ Social: <ul style="list-style-type: none"> <li>- Good design quality of house, User comfort, Social network &amp; solidarity, High residential densities, etc.</li> </ul> </li> <li>○ Economic: <ul style="list-style-type: none"> <li>- Resource conservation, Affordability &amp; availability in the market, Employment opportunity, etc.</li> </ul> </li> <li>○ Environment: <ul style="list-style-type: none"> <li>- Pollution prevention, Waste treatment, Infrastructure, Efficiency (Water, energy &amp; material), etc.</li> </ul> </li> </ul>	Salman, Carlton, Olsen and Irtishad (2011)	<p>Aspects of sustainable design:</p> <ul style="list-style-type: none"> <li>○ Building orientation (selecting a good orientation can reduce energy costs)</li> <li>○ Building massing (to analyse building form and optimize the building envelope)</li> <li>○ Day lighting analysis</li> <li>○ Water harvesting (reducing water needs in a building)</li> <li>○ Energy modelling (reducing energy needs and analysing renewable energy options can contribute to low energy costs)</li> <li>○ Sustainable materials (reducing material needs and using recycled materials)</li> <li>○ Site and logistics management (to</li> </ul>

- reduce waste and carbon footprints)
- Nguyen & Veronica (2003)
- Dimension of sustainable housing:
- o Harmony with the environment (En)
  - o Environment protection (En)
  - o Infrastructure (En)
  - o Energy saving (En + Ec)
  - o Long-term/ flexibility/ durability (En + Ec)
  - o Resource conservation (Ec)
  - o Affordability (Ec)
  - o Business opportunity (Ec)
  - o Fulfil all economic requirements (Ec)
  - o Beautiful (S)
  - o Good design (S)
  - o Convenience for user (S)
  - o Full fill all social requirements (S)
  - o Ownership/ administration (S)
  - o Type of house (detached) (S)
  - o Neighbour relationship (S)
  - o Appliances (S)
  - o Safety (S)
  - o Feng sui application (S)
  - o Location (S)
- Note: En= Environmental, Ec=Economical, S=Social
- Mickaityte, Zavadskas, Kaklauskas, and Laura (2008)
- Sustainable refurbishment principles. Sustainable refurbishment must reconcile further dimensions:
- o Social (collaboration, public awareness and education, social safety, etc.);
  - o Ecological (ecological construction materials, energy, waste, noise, land use, health, air quality, etc.);
  - o Economic (cost-efficient price, fair price and good service, energy saving reliability, etc.);
  - o Cultural (cultural heritage, behavioural norms, etc.);
  - o Architectural (comfort, aesthetics, decoration, environment, buildings purposes matching exterior, etc.);
  - o Technical (innovative HVAC technologies, energy saving technologies, etc.).
- Gupta and Chandiwala (2008)
- Code for sustainable homes categories with environmental weightings:
- o Energy
  - o Water
  - o Materials
  - o Surface water run-off
  - o Waste
  - o Pollution
  - o Health and wellbeing
  - o Management
  - o Ecology
- Edwards (2000)
- Principles of sustainable housing design:
- o Sustainable features in neighbourhoods level:
    - High density, mixed use, and diversified tenure.
    - Integration of land use and transport planning with emphasis upon public means of transportation.
    - Urban layout that creates shelter and safety.
    - The exploitation of renewable energy supplies (wind, sun, etc.)
    - Capture of rainfall for certain water uses.
    - Use of open space to facilitate social interaction and ecological wellbeing.
    - Pollution and waste strategies.
    - Creation of natural habitats integrated with housing.
  - o Sustainable features in individual building level:
    - Healthy, comfortable, secure homes.
    - Householder able to adapt or extend space.
    - Designed-in ability to upgrade.
    - Low energy design exploiting renewable energy sources.
  - o Super-insulated homes.
  - o Low water consumption.
- Mulliner and Maliene (2011)
- Sustainable housing affordability criteria:
- o Access to employment opportunities
  - o Energy efficiency of housing
  - o Interest rates and mortgage availability
  - o Availability of affordable home ownership products
  - o Access to and quality of transport services
  - o Access to health services
  - o Access to and quality of schools
  - o Access to shops
  - o Safety (low crime levels)
  - o Access to open green public space
  - o Access to open child care
  - o Access to leisure facilities
  - o Availability of waste management facilities
- Ross, Bowen and Lincoln (2010)
- Principles of sustainable construction:
- o Minimize resource consumption
  - o Maximize resource reuse
  - o Use renewable, recyclable or recycled resources.
  - o Protect the natural environment
  - o Create a healthy, non-toxic

<p>United Nations Human Settlements Programme (2012)</p>	<p>environment</p> <ul style="list-style-type: none"> <li>○ Pursue quality in the built environment</li> <li>○ Promote socio-economic upliftment</li> </ul> <p>Sustainable houses by UN-Habitat:</p> <ul style="list-style-type: none"> <li>○ Healthy, durable, safe, and secure.</li> <li>○ Affordable for the whole spectrum of incomes.</li> <li>○ Using ecological low-energy and affordable building materials and technology.</li> <li>○ Resilient to sustain potential natural disasters and climate impacts.</li> <li>○ Connected to decent, safe and affordable energy, water, sanitation, and recycling activities.</li> <li>○ Using energy and water most efficiently and equipped with certain on-site renewable energy generation and water recycling capabilities.</li> <li>○ Not polluting the environment and protected from external pollutions.</li> <li>○ Well connected to jobs, shops, health, and child-care, education, and other services.</li> <li>○ Properly integrated into, and enhancing, the social, cultural and economic fabric of the local neighbourhood and the wider urban areas.</li> <li>○ Properly run and maintained, timely renovated and retrofitted.</li> </ul>	<p>Pullen, Arman, Zillante, Zuo, Chileshe and Wilson (2010)</p>	<p>Affordable and sustainable dwelling is:</p> <ul style="list-style-type: none"> <li>○ A product where the rent or mortgage repayments do not exceed 30% of household incomes for the bottom 40% of income groups.</li> <li>○ A product that is appropriately located.</li> <li>○ A product that is of a suitable size and quality for its occupants.</li> <li>○ A product that does not increase the incidence of housing stress over the lifecycle of the house.</li> <li>○ A product where individual and government financial obligations can be met on an on-going basis without policy change.</li> <li>○ A product that is socially acceptable.</li> <li>○ A product that does not increase social exclusion or polarisation.</li> <li>○ A product that is located on a site that minimises biodiversity losses.</li> <li>○ A product that is located on a site that maximises low-energy transportation options.</li> <li>○ A product that encompasses the following environmental features</li> </ul>
<p>Queensland Department of Public Work (2008)</p>	<p>Three fundamental aspects of sustainable home:</p> <p>Environmental sustainability:</p> <ul style="list-style-type: none"> <li>○ Energy (maximises the use of natural energy and minimises the need for non-renewable energy)</li> <li>○ Water (fixtures, fittings and appliances, saves water)</li> </ul> <p>Social sustainability:</p> <ul style="list-style-type: none"> <li>○ Human comfort (thermally, visually and acoustically comfortable)</li> <li>○ Human health (reduces hazards to human health within the home)</li> <li>○ Safety (the design minimises the possibility of falls, driveway run-overs, burns and poisoning and enhances the ability to supervise children in outdoor play areas)</li> <li>○ Security (reduce crime and protect the home from malicious intruders)</li> </ul> <p>Economic sustainability:</p> <ul style="list-style-type: none"> <li>○ Initial costs (cost of construction and cost of building materials)</li> <li>○ Maintenance costs (durable and low maintenance materials)</li> </ul>	<p>Ibem and Azuh (2011)</p>	<p>Parameters for sustainability assessment of Public Housing Programmes:</p> <p>Environmental &amp; Technological Dimensions:</p> <ul style="list-style-type: none"> <li>○ Quality of Housing Environment</li> <li>○ Quality of Neighbourhood Environment</li> <li>○ Housing Density/Building Type</li> <li>○ Architectural solution to energy consumption issues( e.g. ventilation, lighting, building morphology)</li> <li>○ etc.</li> </ul> <p>Economic Dimension:</p> <ul style="list-style-type: none"> <li>○ Housing affordability</li> <li>○ Job creation in the form of home based enterprise</li> <li>○ Tenure options</li> <li>○ Suitability of housing acquisition process</li> <li>○ Cost of living within the neighbourhood</li> <li>○ Adaptability of housing units for future needs</li> <li>○ etc.</li> </ul> <p>Social Dimension:</p> <ul style="list-style-type: none"> <li>○ Access to social infrastructure</li> <li>○ Social networks capable of generating social capital</li> <li>○ Provision of recreational/ sporting facilities</li> <li>○ Security and safety issues</li> <li>○ etc.</li> </ul> <p>Cultural Dimension:</p>

- Architectural design of housing in relation to cultural values of residents
- Suitability of housing to occupants' natural way of life
- etc.

- Rational use of material
- Meeting customers' expectations
- Optimization of quality and expenses
- Life cycle management

Akadiri, Chinyio and Olomolaiye (2012)

Resources conservation:  
 1. Energy conservation  
 2. Material conservation  
 3. Water conservation  
 4. Land conservation

Cost efficiency

1. Initial cost (Purchase cost)
2. Cost in use
3. Recovery cost

Design for human adaptation

1. Protecting Human health and comfort
2. Protecting physical resources

Yu and Kim (2010)

A green building should include some of the following characteristics concerning land used, site locations, materials used, energy efficiency, water efficiency, surface water management, pollution, and health and wellbeing of occupants:

- Effective use of existing landscapes
- Site use, community development and transport requirement
- Use of energy efficient and eco-friendly equipment
- Use of recycled and environmental friendly building materials
- Indoor air quality for human safety and comfort
- Efficient use of water
- Use of non-toxic and recycled materials
- Use of renewable energy
- Effective controls and building management system
- Effect on bio-diversity of the present ecosystem

Narvydas (2014)

Principles of sustainability in construction:  
 Environmental:

- Minimal use of resources and energy
- Usage of ecological material
- Reuse of materials
- Protect of biodiversity

Social:

- Healthy and safe environment
- Social cohesion and social justice
- quality of life
- Cultural diversity

Economic:

Relevant factors have been taken into account in the SHD conceptual framework building. After that, all factors have been divided and grouped into four main dimensions according to similar characteristics of those factors. The proposed four dimensions were physical, social, environmental, and economic dimension. Figure 3 shows the proposed SHD conceptual framework. Based on the framework, each dimension of SHD consists several relevant indicators that have an influence on the SHD. The steps involved in developing a conceptual framework for the SHD:

- I. Lists the all indicators of sustainability through literature review.
- II. Analyse each factor and classify them according to different dimensions: the physical, social, environmental, and economic dimensions.
- III. Make sure every indicator is grouped according to exact dimensions. Each dimension will be pointing at the target (SHD) as a reflection of the relationship between the two variables.

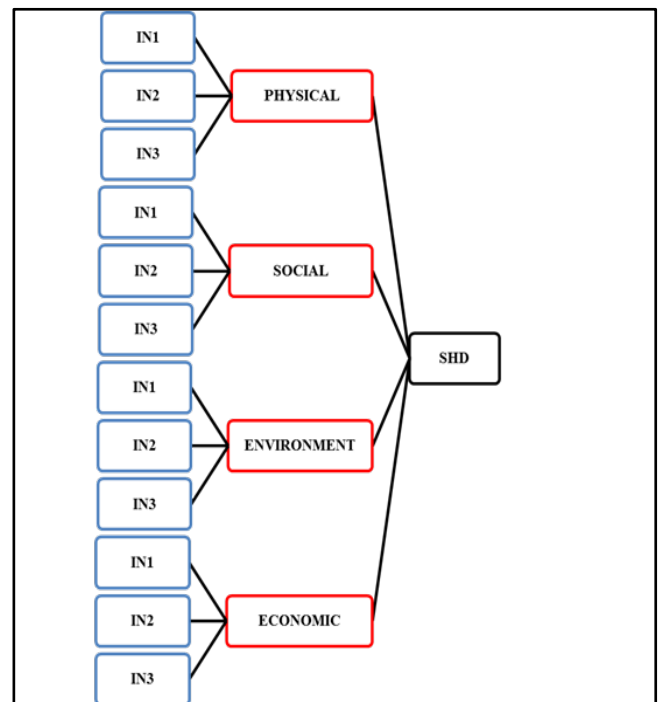


Fig. 4. Basic conceptual framework of SHD.



The conceptual framework can be used to develop sustainable housing model based on a systematic study. The data collected for each indicator will reflect the degree of sustainability of a housing development. Not all the factors that gathered will be used in the development of the assessment model. It should be modified by accepting the relevant factors and ignore irrelevant factors. For example, local cultural factors need to be considered in the process of modifying the model because the culture is different according to race and ethnicity. Thus, awareness of cultural factors must exist in a housing area inhabited by a single race or multiracial community. A notable example for that is *Feng Sui* application which is an ancient Chinese system of aesthetics believed to use the laws of celestial (astronomy) and Earth (geography) to help improve a person's life. Therefore, this item cannot represent the sustainability of a house that occupied by an individual or a group of individuals who do not have that trust.

#### 4 CONCLUSION AND RECOMMENDATION

Overall, this paper has presented a brief process of a conceptual framework building for sustainable housing. This paper systematically lists sustainable housing/building framework or model that was developed by previous researchers. Next, the indicators of sustainability that had been gathered from a range of sources were categorised and grouped into four dimensions of SHD. This paper successfully developed a conceptual framework for sustainable housing development. It is hoped that the conceptual framework presented can be used by other researchers in the future to assess and measure the level of housing development based on different dimensions of sustainability. The establishment of a sustainable housing development model should be modified according to specific objectives of each study and therefore it can help to improve the accuracy of instrument in measuring or assessing the level of sustainability.

Housing developed in a sustainable manner for present and future generations is not a dream that is difficult to achieve. It can be achieved through a systematic and structured process with continuous effort. In the development process, various stakeholders participate in determining the overall housing development based on the policies and predefined rules. The stakeholders have a specific expertise in order to ensure the success of any housing development plan. Therefore, the development of human resources with useful and practical knowledge and skills should be continued and strengthened over time. To implement sustainable housing development plan, house builder or house contractor requires a wide range of human

resources, including skilled workers, semi-skilled and unskilled workers to carry out a housing construction project and they should follow the specific policies and regulations related to the sustainability characteristics that were set up by the sustainability designer during the planning stage. More importantly, the government should play a leading role in designing and presenting overall direction of the housing development. In terms of planning, some important elements should be considered, such as land-use trends and composition, the number of existing houses, the total population, density and so on. For example, considerations on the number of existing houses and the number of households that exist allow prediction of the housing needs for the future. Furthermore, an effective housing development plan should be managed by stakeholders efficiently and effectively through a good governance system. This is why good governance has been acknowledged as a pre-requisite for sustainable development (Sanday, 2003).

Compared with developed countries, Malaysian society still lacks awareness in terms of sustainable housing development. This may be caused by lack of disclosure and information about sustainable housing which have not been widely disseminated in society. Although the government has been implementing the concept of sustainable development through several development plan, but implementation and effectiveness of the policies are still dubious. Furthermore, rural communities have long been comfortable with houses in village and its atmosphere. For them, sustainable housing is a comfortable house that is able to meet their individual needs such as low living cost, cosy village atmosphere, no traffic jams and excessive entertainment. Relatively, urban communities prefer modern housing with updated equipment and facilities. In addition to that, it should be emphasized that other factors, mainly demographic factors also have an effect on the overall SHD. For example, total household income affects the purchasing power of households. Liabilities such as non-working spouse, medical needs for children and the elderly and children who are still studying cause the household living cost become higher. Constraints in terms of financial resources led to households experiencing social and economic pressures and the opportunity to improve housing sustainability has become limited. The explanations above tried to clarify that sustainable housing should respond to the local needs and take into account all related and significant factors that also have an impact on the housing development as a whole in order to ensure the real sustainable outcome.

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