

# TRANSFORMING TERRACE HOUSING ROOFTOP TO GREEN ROOF IN KUALA LUMPUR – A STUDY ON ITS CONSTRUCTS & VARIABLES

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## ABSTRACT

The constricted planning design of most intermediate terrace housing built in Malaysia has impoverished access to personal green space that could render a better living condition to its occupants. Thus, the idea of retrofitting green roof to the existing terrace houses in Kuala Lumpur is advocated as an alternative green space within the unit. This paper attempts to investigate the many significant constructs and variables that may influence the owner-occupants' acceptance of the green roof. Literature reviews are undertaken as a methodology. Attitude towards use, subjective norms and perceived behavioural control are found to be relevant as the main constructs. Others variables include health, leisure, comfort, redundancy, aesthetic, safety, return of investment, capital, spatial needs and privacy.

**Keywords:** *Green Roof / Green Space, Housing Transformation, Housing Satisfaction, Acceptance*

## INTRODUCTION

The growth of urban population worldwide has increased rapidly in the past few decades (UN, 2008). It is continually putting immense pressure on urbanization, particularly in the developing countries. In most cases, the existing physical infrastructure of the cities could not cope with the trend and in the process implicated many social and environmental issues (Fuller, 1993, Lawrence, 2004). Among the issues faced are the shortages of housing and green spaces (Home, et. al. 2009).

Housing is a basic social need that is necessary for shelter, living and security for the family as highlighted in the Malaysian Quality of Life Index (2007). Since the 5<sup>th</sup> Malaysia Plan (1986-1990), the government has introduced the concept of human settlement with the emphasis on the living environment and the people as its focus of development. This longstanding commitment is now carried through in the 11th Malaysian Plan with the updated objective of ensuring access to quality and affordable housing as well as promoting an efficient and sustainable housing industry. However, in the rush to provide shelter for the growing population, some of the housing design (e.g. terrace houses, flats) imposed negative impacts to the quality of life and social patterns of the residents (Tan, 1980; Sulong, 1984; Nurizan, 2000, Mohit et. al., 2009).

Studies have shown the positive contributions of greenery to the living quality and the residents' satisfaction either with their housing unit or the neighbourhood (Hur, M et.al, 2009; Amerigo, 2002). Due to the lack of outdoor space that is not usable an inaccessible within the residents confined housing area, city dwellers are beginning to migrate to the suburb (Valentine, 1997; Chawla, 2002). It shows that green space is a determinant to the quality of life of the residents (Lawrence, 2000; 2004; Malaysian Quality of Life, 2004) and also reflects the residents' concern for health especially on their children's mental growth (Karsten, 2006).

The focus of literature reviews will explore on the following aspects:

1. Housing and green space (e.g. What do the residents understand about green space within their terrace house unit?)
2. Housing and transformation (e.g. Why do people renovate and modify their house?)
3. Housing and satisfaction (e.g. What gratify the residents)
4. Green roof (e.g. What is green roof and its benefits?)
5. Acceptance behaviour (What are existing theories on acceptance model available?)

The overall focus of the literature reviews is shown below:

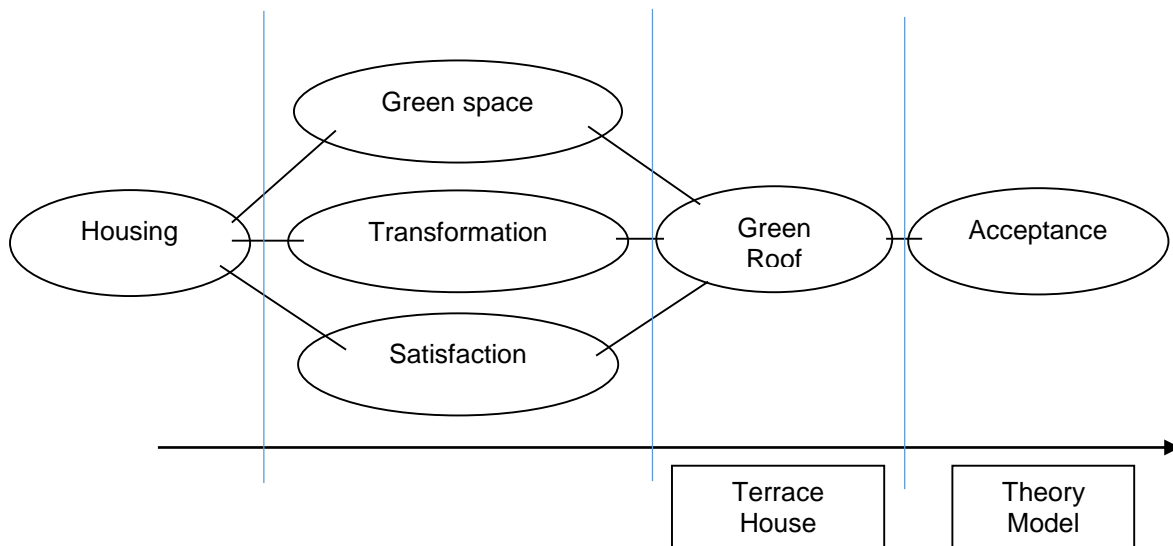


Fig. 1: Literature Framework

## TERRACE HOUSING IN MALAYSIA

Terrace housing proliferated in quantity during the 1970's and has become one of the most prominent and popular housing typology preferred by majority of Malaysian (REHDA, 2004, Prasad, 2005). It is defined under the Uniform Building By-Laws (UBBL, 1984) as "residential building designed as a single dwelling unit and forming a part of a row or terrace of not less than three such residential buildings". Statistically, it is coded into a 1-storey, 1½-storey, 2-storey, 2½-storey, 3-storey and above in term of height references (Department of Statistic, 2009). Since it comes in variety of design/different floor areas, the price varies thus attracts many buyers from different income groups. Sadly, it is designed only to reap the most profits from the land available i.e. by maximizing the number of units and rather monotonous in façade treatment.



Fig. 2: A typical view of terrace housing development in Malaysia

Terrace housing design in a scheme is often categorized logistically by being the intermediate, the end or the corner unit. The intermediate units are those flanked by other units and are the majority in any development. The end units are the one located at the end of a row and normally bordered by a 10 feet access road to allow for fire break and access to back alley. The corner unit is the most spacious and located at the end of the row with the inclusion of a minimum 20 feet wide land at its side. It is noted that the intermediate and the end unit are units often deprived of green space.

The lot sizes of the intermediate units vary from 14' x 55' to 20' x 70'. There are bigger units sizing from 20'x80' but are mostly older units. Generally, the units have common characteristics, except those located at prime areas which are normally smaller in size and priced higher due to the land cost. Most of the units are designed in rows with back alleys. Majority of the units are those with front/back facing each other.

According to the report on existing terrace housing stock, there are 67,457 units (2 - 3storey) and 22,210 units (1-storey) constructed by both private and public sectors (Department of Valuation and Property Services, 2010). Some of the units are built more than two decades ago. In view of the dilapidating state and constricted design of many of the houses, as well as to optimize land use (many cannot afford to move elsewhere), the Kuala Lumpur City Hall (DBKL) has issued guidelines that allow extensions of the terrace houses to up to 3-storey high (DBKL, 2007). DBKL's initiative for a leeway to terrace housing renovation is in line with Kuala Lumpur Structure Plan 2020 in providing among others "*good quality housing*", "*a healthy, safe and lively environment*", "*enjoy the best possible standard of living*" and "*a clean, healthy, safe and caring environment that caters to the needs of all*".

The constricted spatial planning in most of the intermediate terrace housing has left the residents with no access to private green open space outside their immediate house. This has adversely affected the health development of the households, especially the children, the old and the handicapped (Karsten, 2006). One of the observed criteria for healthy living lacking in most intermediate/end terrace houses is the non-availability of green space. Accessibility to green space in the confined of the typical intermediate terrace housing unit is in fact non-existence. The only green space at the front of the house is normally paved and covered with car porch. Similarly, the backyards are designed to cater for utilities such as drying or wet kitchen. It is common to find houses that have extended their walls up to the boundary to cater for a larger indoor space. As a result, many residents attempt to create green space on their balconies or porch's roof.

The roof of a typical terrace house intermediate unit is commonly pitched in form and made from hard clay/concrete tiles. Confined beneath it is the neglected structural space to cater for storage of mechanical items such as water-tank, -heater, -piping, electrical wiring etc. The area is inhabitable during the day due to heat and is a potential pests' hideout at night. It also poses security hazard such as fire break out and break-ins through the roof tiles. The

potential of the main roof as a usable area for green space and simultaneously resolve other problems has yet to be propagated and widely accepted, especially in the context of the many existing terrace houses in Malaysia.

### THE NEEDS FOR GREEN SPACE

Research across different disciplines has shown that open space, particularly involving greenery has directly benefits the urban environment and makes the city more livable. (Rogers and Urban Task Force, 1999; Partners for Livable Communities, 2000; Van Kamp et al., 2003). Dwyer (1992) found that greenery actually gives a cooling effect to the environment whilst other researchers like Ulrich and Simons (1991) have studied on human benefits. Ulrich (1984) for example is widely cited for illustrating the restorative health benefits that greenery-view windows can have on patient's recovery. Miller (1986) and others such as Thompson (2002) show that the desire for contact with nature will only increase as people become more urban in their way of living.

Correa (1989) highlighted the two most important aspects of living in the urban, i.e. the element of covered spaces and open-to-sky spaces, and secondly, the interdependency of these two factors. The former is a fundamental significance in developing countries with tropical climates where activities take place outdoor. The study in Bombay showed that the spatial system has a hierarchy, i.e. space for private use (cooking, sleeping etc.), space for intimate contact (front doorstep for play and chat), space for neighborhood meets (water tap area) and space for the principle urban area (community space). The second factor is how these spaces are linked to each other, i.e. the lack of space in one category can be adjusted by providing more space to the others.

Green space could also be associated with other needs of the residents such as privacy and space for social-cultural adaptations. Ahmad, H. et al. (2006) findings showed that the lack of space in terrace housing in Malaysia resulted in privacy being negotiated, compromised or lost, even after modifications of the house. Modification or transformation of the house occurs when the design is not congruent to the way of life of its residents, resulting in behavioral adaptation. The neglect towards cultural and religious needs of the residents may cause negative long term consequences and changes the lifestyle of its residents which are against their desired way of life (Zaiton, 2007).

Earlier studies by Wilson (1984) used the term biophilia to describe the attractions and positive feelings that people have towards living systems. These include plants, animals and even weather and he showed there is a significant impact natural environment has on people. Similarly, Kaplan & Kaplan (1989) in their Attention Restoration Theory also suggested the great impact that landscape has on human. They studied the effects of nature on people's health and relationship and discovered that office workers with just a view of nature were healthier and happier at work. It proved that nature can lift up people's mood and improve ability to focus and really help to improve self-contentment and thus wellbeing.

Green space, as a sustainable landscape element, can facilitate leisure and recreational activities, improve health of its users with therapeutic effects as well as foster community interaction. Dwyer et. al (1994) proved that the setting for outdoor recreational pursuits for urban residents can provide enjoyment especially to the elderly, handicapped and the young who were more dependent on near-home recreation spaces. This is most relevant for terrace housing as it can provide a private escape for the occupants. Johnston & Newton (1996) also asserted that green space, particularly green roofs can provide opportunities for a more secluded, less polluted and less noisy area for informal recreation, especially with the high premium for areas at street levels in the cities.

Many children have lost the outdoor space in urban area, either because it is not usable or not accessible to them (Valentine and McKendrick, 1997; Chawla, 2002) As a result, the lack of outdoor space is affecting the children physically and mentally. It is discovered that children in urban areas with which do not have access to safe open space are more sedentary and obese due to lack of exercise (Veitch, et al (2008).

The Quran has also reminded human on the needs to study vegetation and living as the following:

*"Certainly there was a sign for Saba in their abode; two gardens on the right and the left; eat of the sustenance of your Lord and give thanks to Him; a good land and a Forgiving Lord"*

(Quran, Surah Saba 34:15)

*"And He it is Who sends down water from the cloud, then We bring forth with it buds of all (plants), then We bring forth from it green (foliage) from which We produce grain piled up (in the ear); and of the palm-tree, of the sheaths of it, come forth clusters (of dates) within reach, and gardens of grapes and olives and pomegranates, alike and unlike; behold the fruit of it when it yields the fruit and the ripening of it; most surely there are signs in this for a people who believe"*

(Quran, Surah Al-Anaam 5:99)

## HOUSING AND GREEN SPACE

Green space is one of the components of urban landscape, i.e. together with urban parks and green networks (Greenhalgh and Worpole, 1995). It accommodates a whole range of urban spaces including neighbourhood parks, town parks, linear parks, playgrounds, community gardens, green roof etc. which lie within the urban environment. In the smaller context of terrace housing unit, the definition of green space may vary from one resident to the other. It could be interpreted as an open external space of the house for the family to enjoy outdoor greenery and recreation. However, others could also see it as simply a landscaped area for viewing, or an external covered area without plants, an environmentally friendly area or even an energy efficient space.

Correa (1989) in his study in Bombay highlighted the two important aspects of living in the urban, i.e. the element of covered spaces and open-to-sky spaces, and secondly, the interdependency of these two factors. The former is a fundamental significance in developing countries with tropical climates where activities take place outdoor. It showed that the spatial system has a hierarchy, i.e. space for private use (cooking, sleeping etc.), space for intimate contact (front doorstep for play and chat), space for neighborhood meets (water tap area) and space for the principle urban area (community space). The second factor is how these spaces are linked to each other, i.e. the lack of space in one category can be adjusted by providing more space to the others.

The urban cities can be made more livable by providing significant amount of accessible outdoor recreation or amenity space (Peck ,1999) Given the high premium for areas at street levels in city areas, green space such as the green roof can provide opportunities for a more secluded, less polluted and less noisy spaces for informal recreation (Johnston & Newton, 1996). Research in residential vicinities have shown that green space contributes positively to the living quality and also increases the residents' satisfaction with the housing unit and its neighbourhood (Hur, M et.al, 2009; Amerigo, 2002; Francescato, 2002; Lipsetz, 2000; Amerigo & Aragones, 1997; Carvalho, George, & Anthony, 1997; Marans, 1976)

Green space can facilitate leisure and recreational activities, improve health of its users with therapeutic effects as well as foster community interaction. Dwyer et al. (1994) showed that the setting for outdoor recreational pursuits for urban residents can provide enjoyment especially to the elderly, handicapped and the young who were more dependent on near home recreation spaces. This is most relevant for terrace housing as it can provide a private escape for the occupants. Johnston & Newton (1996) also asserted that green space, particularly green roofs can provide opportunities for a more secluded, less polluted and less noisy area for informal recreation especially with the high premium for areas at street levels in the cities.

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The accessibility of green space is crucial for children. Many children have lost the outdoor space in urban area, either because it is not usable or not accessible to them (Valentine and McKendrick, 1997; Chawla, 2002) As a result, the lack of outdoor space is affecting them physically and mentally. It is discovered that children in urban areas with which do not have access to safe open space are more sedentary and obese due to lack of exercise (Veitch, et al (2008).

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## HOUSING AND TRANSFORMATION

Housing transformation / adjustment / modification involves physical changes to the existing house which reflect discrepancies in terms of housing needs, culture and way of life as described by Rapoport (1992). In this study, transformation implies activities involving extension and alterations to the existing buildings. Transformation indicates that there are discrepancies between what the occupants need against the design condition of the house. Changes are made in order to meet the needs and preferences rather than the need of making good the house due to wear and tear / beautification. Understanding why transformation occurs in housing is crucial to familiarize with the various dimensions affecting the occupant's decision making, thus on their acceptance level.

Some studies purported that housing transformation is a reflectance to the resident's personality, tastes, interest, lifestyle values and social status. They suggested that people are consciously or subconsciously modifying their homes in order to express their personal and social identity in the society. (Rapoport, 1969; Nasar, 1989)

Kirwan and Martin (1972) indicated that transformation decision is made because of the expected benefits to be gained i.e. by the increase in size of the house (floor area, plot size, room number etc.), the housing quality (structure, fittings etc.), location accessibility (to facilities, employment etc.) and environment (neighbourhood character both socially and physically).

Seek (1983) discussed on the decisions on home improvement and implication it has on the housing transformation process in Australia. He purported that house improvement depends on the family life cycle such as in the increase income and household size. In the study, he discovered that the higher income groups actually make up a bigger proportion in numbers in carrying out home improvements. He also developed a conceptual framework that suggested that the final decision in housing adjustment involved two stages i.e. the decision to adjust one's housing consumption and the choice between to move, improve or both. Oxman and Carmon (1986) who carried out a study in Israel also shows similar result i.e. households with higher income tend to invest more in extensions than low-income households.

Another research by Potepan (1989) showed that around 1980's in the United States, high interest rates made house improvement more attractive relative to moving among house owners who held fixed rate mortgages. Moving implied a higher mortgage due to the increase in interest rate. He also identified that for house improvement to be made, plot size, layout plan and the previous construction method plays important roles. Therefore, for minor extension, improvement is the most economical option.

Gostling et. al (1991) on the other hand rejected Seek's claim that extension is due to the family life cycle. Their findings show that extension activity represents a progressive upgrading of the property to achieve higher space standards and quality. The study was conducted in 1987 when there was a booming housing market in United Kingdom. With the raising of housing prices, they found that households were more inclined to extend as the cost of purchasing a larger house is higher. This is added with the scarcity of land and competitive demand for housing that led house owners to extend. Gostling also mentioned on the location and residential environment factors on housing consumption i.e. accessibility to various urban facilities (including employment opportunities) and the environmental quality also plays a major role.

People also expect financial return from the housing consumption e.g. in the form of higher rental income and market value (Tipple, 1997). However, compared to Gostling's view of achieving a higher spatial quality, the study highlighted that the findings in developed countries is different from the developing countries i.e. in the former, households have the option to move or improve, however for the latter, especially the lower income group, seldom move to a new unit.

In Malaysia, study by Ahmad et.al (2006) showed that low cost terrace housing modifications are the result of the lack of privacy, which was lacking in the original design. Other studies abroad had also indicated the same result (Abu Gazzeh (1996); Al-Kodmany (1999); Ozaki (2001). Modifications are also found in stages reflecting the necessity and economic ability of the family. Moving out to another place is not a common practice due to high price and neighbourhood attachment prevalent in the Asian societies (Zaiton, 2007).

## HOUSING AND SATISFACTION

As discussed above, the housing transformation is closely linked to the satisfaction of the occupants. Modification of the house is basically because of the lack of some satisfaction resulting from the changes in the needs of the inhabitants against the existing house design.

In definition, housing/residential satisfaction is the contentment that one has or achieves of one's needs or desires in a house. It has been an important indicator for planners, architects, developers, and policymakers in many ways. According to Djebuarni & Al-Abed (2000) It is used as (a) predictor of the individual's perceptions of general 'quality of life' (b) an indicator of incipient residential mobility (c) an ad hoc evaluative measure on the success of developments constructed by private and public sectors, and (d) an assessment tool of residents' perceptions of inadequacies in their current housing environment in order to improve the status quo.

Items (a) & (d) influence the reasons why this subject is incorporated in this study. From observation, terrace houses which utilize their rooftops for green area or for recreational purposes are very rare and have not widely implemented. Therefore, to study satisfaction of the residents is not very viable as not many residents have actually used it. Therefore, a fundamental study on acceptability of this private green roof needs to be conducted first before further researches are to be conducted.

There are many studies abroad. Rossi (1955) for example postulates that changing housing needs and aspirations occur through the residents' life cycle stages. This would lead to residential dissatisfaction thus migration. Therefore, migration is seen as to increase level of residential satisfaction (Wolpert, 1966)

Resident's judgments on residential conditions are basically based on their needs and aspirations. It measures the difference between households' actual and desired/aspired housing and its neighbourhood situations (Galster, 1987). Therefore, the absence of any complaints and a high degree of congruence between actual and desired situations implies satisfaction, vice versa.

Housing satisfaction is considered as a dynamic process as postulated by Morris and Winter (1975, 1978) known as 'housing deficits'. They theorized that residents judge their housing conditions according to two types of norms, personal or cultural which may not coincide. An incongruity between the actual housing satisfaction and housing norms results in a housing deficit, which in turn gives rise to residential dissatisfaction. This would lead to housing adjustments which may be either in situ such as revising their housing needs and aspirations in order to reconcile the incongruity, or improving their housing conditions through remodelling, or moving to another place and bring their housing into conformity with their aspirations or needs.

However, the above require that the residents should have enough information about alternative adaptation opportunities and financial resources. Some empirical studies have demonstrated that housing deficit is a useful concept in explaining residential satisfaction and mobility behavior (Bruin & Cook, 1997; Husna & Nurizan, 1987)

## GREEN ROOFS

Green Roofs or also known as roof garden, living roof or eco roof can be defined in two perspectives. Generally, it is defined as building or structure that accommodates vegetation on its roof tops, i.e. by having either a shallow soil cover (extensive green roof) or deep soil



cover (intensive green roof). Green roofs are also in fact a smaller scale or pockets of urban green spaces. As in this study, the exception is that green roof is elevated away from ground. Alternatively, it can also be interpreted as roof tops that accommodate green technology such as photovoltaic panels, rain water harvesting, solar heater etc.

Rooftop's utilization as green open space is not new in Malaysia. Green roof can be seen in different type of building type such as commercial, public, institutional and even residential (e.g. condominiums) However it is very rare to find a terrace house that uses it. With the current scenario of urban area problems such as the shortage of land, urban heat island, crime, inflation, water shortage, design spatial constraints etc., rooftop greening seems to be a viable solution. There are many studies conducted on the environmental aspect of green roofs but not many on the socio-economic perspectives, especially in Malaysia.

The definition of green rooftops in this paper is limited to buildings with vegetation on flat rooftops (i.e. either soil covered or potted plants) which is accessible as private green open area, thus looking at green rooftops and its relationship with housing. The focus is to find theoretical background as a support to the hypothesis that the green roof is acceptable by the people in the terrace housing areas and it could improve the living quality of its occupants.

Green roof can mitigate not just the environmental issues but also on socio-culture of a place. It provides additional space to the occupants which would otherwise is left vacant, redundant or use for services. Among others, green roof can facilitate leisure and recreational activities for the family. It could also improve community interactions if is made accessible to the neighbours. The community of a housing area would have the opportunities to create communal garden for various activities, thus improving participation of the residents. This would foster better interaction, create a feeling of co-ownership and security as green roofs are quite protected semi-public area, away from ground.

Dwyer et. al (1994) proofs that the setting for outdoor recreational pursuits for urban residents can provide enjoyment especially to the elderly, handicapped and the young who are more dependent on near-home recreation spaces. This is most relevant for terrace housing units as it provides a private escape for the occupants and is supported by Johnston & Newton (1996) which asserts that green roofs provide opportunities for a more secluded, less polluted and less noisy spaces for informal recreation especially with the high premium for areas at street levels in the cities.

Wong et.al. (2003) in a study on thermal benefits of green roofs found that surface temperatures measured under different kinds of vegetation were much lower than that measured on the hard surface. The heat transfer through the bare roof was greater than that through planted roofs and roof with only soil. Also the plants cooling effects was confirmed by ambient air temperatures measured at different heights. Green plants also irradiated and reflected less solar heat by the measurement of reflected solar radiation on site. The study proved that in a tropical country, plants coverage is critical in reducing heat absorption through roof. The reduced heat gain to the terrace house will improve the comfort level, thus improve the wellbeing of its occupants.

Having landscape on roof tops is pleasing to the eye and is an attraction to urbanites that provides visual contrast and relief to the highly-built up city environment (Dwyer et al 1994). Green roofs provide habitats for flora and fauna to grow thus could improve aesthetic appeal. It can also hide ugly rooftop services which sore the view, especially for residents and workers in high rise developments which often look down on large expense of asphalt, tiles, and chillers of the flat roofs (Johnston & Newton, 1996)

Cultivation of vegetables and food is also a possible option for green roof. Laman Padi in Langkawi is an example of the possibility of cultivating paddy as proposed by Datuk Seri

Sanusi Junid, the former Chief Minister of Kedah. Although the proposal is not carried out widely, yet the idea is viable. Graneme (1998) highlighted an agricultural firm (Annex Organics) that managed to produce saleable tomatoes using innovative semi-hydroponics system on a roof garden in Toronto. Even Changi Hospital has harvested several crops of leafy greens and fruits, including 150kg of cherry tomatoes from hydroponics planters on its roof top (Nathan, 1999)

Economically, provision of green roofs would give a higher value to the property. It is a social benefit to the community and an added value especially to units that are fronting the green roofs. Studies in America and UK show that good tree cover increases property value by 6-15% (Peck et al, 1999)

Yuen & Wong (2005) found that people in Singapore are also supportive of the provision of green roofs/roof gardens. However, it highlights that its usage is highly dependent on the resident's needs and concerns. The study showed that the gap that exists between the residents' awareness and usage of green roofs require closer analysis of the residents' needs, interests and knowledge of green roofs. This relates to an important but often overlooked phenomenon of non-use in green urban park provision as supports by Jacobs (1961) and Burgess et al (1988). These findings are only unique to Singapore which involves high rise green roofs for public use and it opens up relevancy between terrace/low rises residential applications of green roof in term of the resident's needs and concerns. Study on its need is yet to be done particularly in the Malaysian context.

In financial term, extensive green roof cost is not more than that of a conventional flat roof and bring about positive net savings i.e. upon considering energy savings in the long run (Wong et.al, 2005). The study demonstrates that although an extensive green roof (rooftop with shallow soil coverage of approximately 100mm) is much higher initially, the life cycle cost is greatly reduced. However, this is not true when applying intensive green roof with deep soil coverage. Therefore, application of extensive roof garden is a more viable option for terrace housing. An even cheaper solution is by applying potted plants on flat roofs which gives the same garden effect.

## ACCEPTANCE BEHAVIOUR

It is crucial to understand the social behaviour on acceptance, especially with new innovations. Before looking at the models, Diffusion of Innovation theory is studied as to understand the decision making process.

Diffusion of Innovations is a theory of how, why and at what rate new ideas and technology spread through cultures (Rogers, 1962). This theory seeks to explain the spread of new ideas or innovations. There are 4 main elements that influence the spread of a new idea i.e. the innovation, communication channels, time and a social system. In other words, diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.

Rogers purported that there are five stages in the innovation adoption process as below:

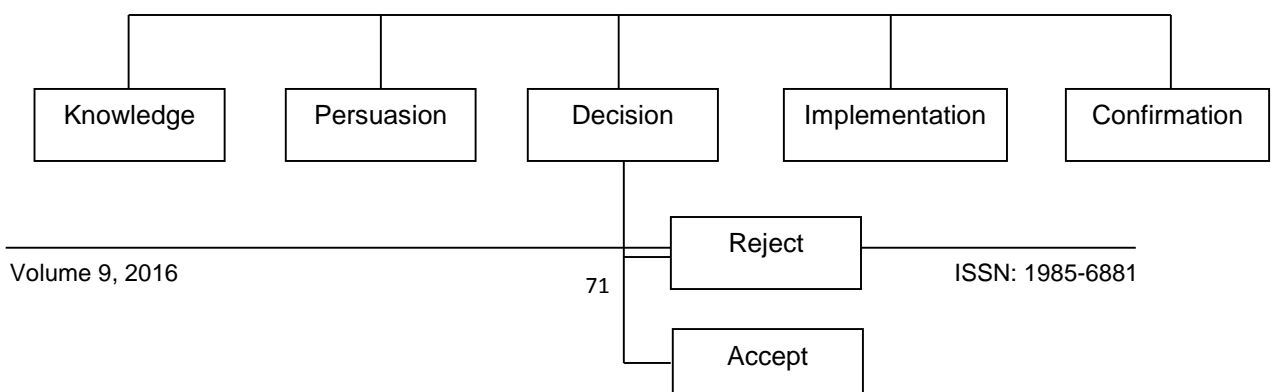


Fig. 3: Diffusion of Innovations Theory

The first is the knowledge stage where the individual is first exposed to an innovation but lacks information about the innovation. During this stage of the process the individual has not been inspired to find more information about the innovation. In this research, this is the stage that is currently observed.

Secondly the persuasion stage, where the individual is interested in the innovation and actively seeks information/detail about the innovation. In the third stage i.e. decision, the individual takes the concept of the innovation and weighs the advantages/disadvantages of using it and decides whether to adopt or reject the innovation. Rogers notes that it is the most difficult stage to acquire empirical evidence due to the individualistic nature. In this implementation stage the individual employs the innovation to a varying degree depending on the situation. During this stage the individual determines the usefulness of the innovation and may search for further information about it. Finally, the confirmation stage where the individual finalizes their decision to continue using the innovation and may use the innovation to its fullest potential.

## BEHAVIOURAL MODELS

Three theories or models of acceptance behaviour are studied in this research. The 1st would be the Technology Acceptance Model (TAM) (Davis,1986;1989) This theory basically suggested that behavioural intention to use a new technology is much affected by the user's perceived ease of use and perceived usefulness.

The model is as below:

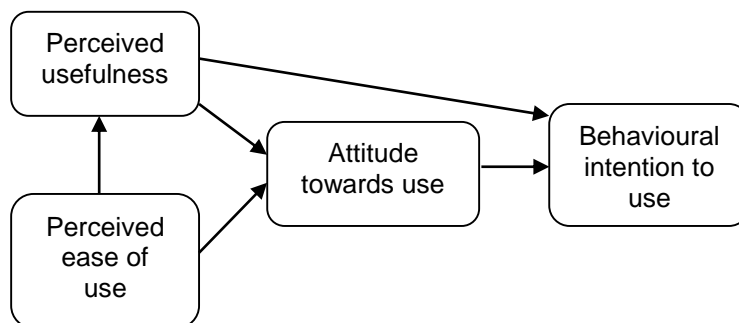
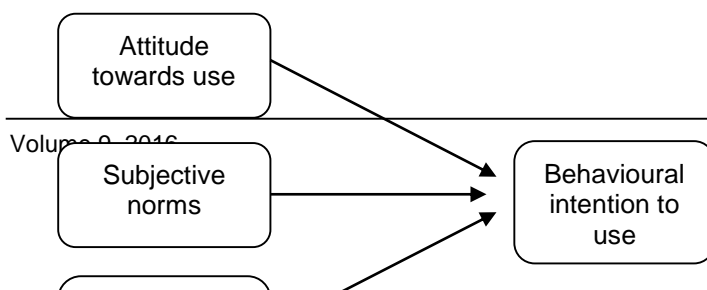


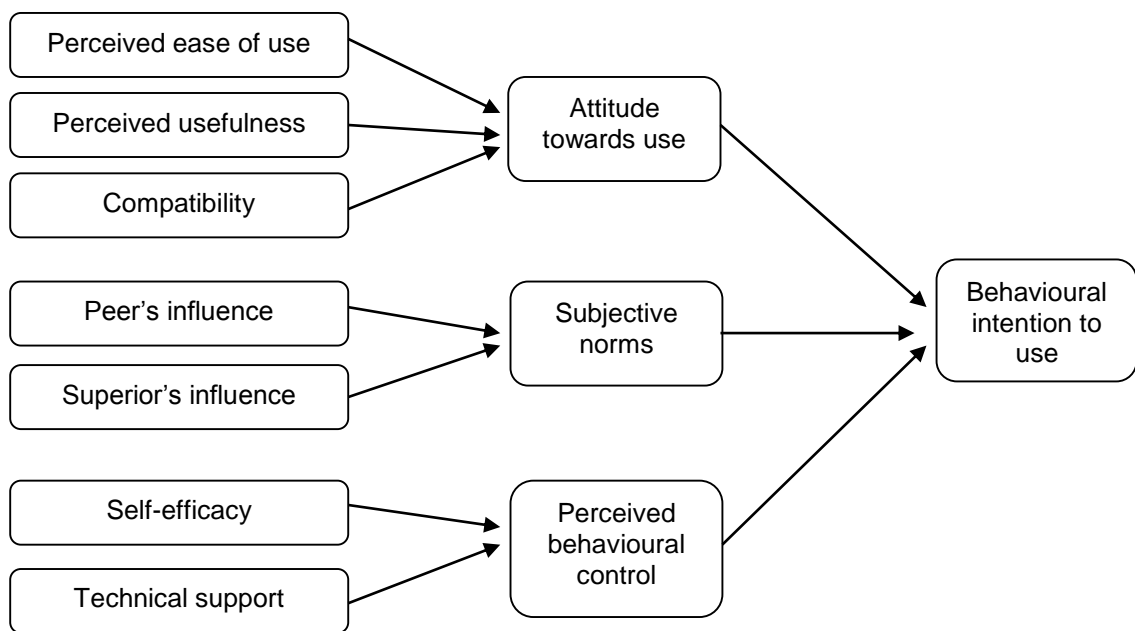
Fig. 4: Technology Acceptance Model

Secondly, the Theory of Planned Behaviour (TPB)(Ajzen,1988, 1989). Ajzen extended his previous Theory of Reasoned Action (TRA) and postulated that the behavioural intent is affected by 3 joint factors i.e. attitude towards use (positive or negative), subjective norms (influence of significance others) and the perceived behavioural control (internal and external constraints e.g. resources, knowledge etc.) (TRA do not have this 3rd factor). The model is as shown below.



*Fig. 5: Theory of Planned Behaviour Model*

Finally, the last theory is the Decomposed Theory of Planned Behaviour (DTPB) (Taylor and Todd, 1995) which took TPB as its basis by identifying further the various belief factors that influence each of TPB determinants. The first i.e. attitude is decomposed into perceived ease of use, usefulness and compatibility (Lin, 2007; Taylor and Todd, 1995) The 2nd determinants i.e. the subjective norms are affected by peer's and superior's influence (Taylor and Todd, 1995; Huang and Chuang, 2007) and the last determinants, the perceived behavioural control is influenced by self-efficacy and technical support (Huang and Chang, 2005; Huang and Chuang, 2007). The summary is as below:



*Fig. 6: Decomposed theory of Planned Behaviour Model*

DTPB model is a relevant theory of acceptance and could be adopted into this research. Subsequently, future measurements will have the purpose of testing and validating the research hypothesis as well as reaffirming the DPTB theory. The constructs and dimensions to be measured based on the above model is defined as below:

|   |  |
|---|--|
| Perceived usefulness<br>( <i>Tanggapan Berguna</i> )      | The degree to which the owner-occupant of terrace housing believes using Green Roof would enhance his performance.                             |
| Perceived ease of use<br>( <i>Tanggapan Mudah Guna</i> )  | The degree to which the owner-occupant of terrace housing believes that using Green Roof would be free of effort.                              |
| Compatibility<br>( <i>Keserasian</i> )                    | The degree to which the Green Roof fits with the owner-occupant of terrace housing style and all aspects of living needs.                      |
| Peer's Influence<br>( <i>Pengaruh Kenalan Setanding</i> ) | The terrace housing owner-occupant perception of their neighbours'/friends'/spouse opinions on having Green Roof.                              |
| Superior's Influence<br>( <i>Pengaruh Pihak Atasan</i> )  | The terrace housing owner-occupant perception on the opinion/restriction of local authority (DBKL)/Residence Association on having Green Roof. |
| Self-Efficacy<br>( <i>Kemampuan Diri</i> )                | The terrace housing owner-occupant perception of his/her ability to use Green Roof in his everyday living.                                     |
| Technical Support<br>( <i>Sokongan Teknikal</i> )         | The terrace housing owner-occupant perception of the support/assistance from the consultants/suppliers when using Green Roof.                  |

## CONCLUSION

The inherent capacity and potential of green space, particularly green roof in providing a healthier living condition (physically and mentally) to the terrace house occupants has not been studied empirically in Malaysia. A clear definition of what is green space in the context of terrace housing unit must be clearly established due to the different perceptions that may exist.

It is also important to understand the needs and concerns of the occupants in order to make green roofs work as highlighted by Yuen and Nyuk Hien (2005). Being a tropical country, the elements of open and covered areas are crucial in the design of these green spaces. Among the main dimensions derived from the studies are health (biophilia and restorative theory), privacy, leisure, comfort, redundancy, aesthetic and safety.

With regard to housing transformation, there are different affecting factors between the developed and developing countries. Its relevance to the local context requires further scrutiny. A medium to high cost terrace housing units are more appropriate as purported by Seek (1983) and Oxmon & Carmen (1986) i.e. the higher the value of the units, the likely they are to be occupied by a higher income group with interests with green roof. The main variables derived from the studies are return of investment, capital required (due to income & interest rates), spatial needs (due to family life cycle) and privacy.

Lastly, the foregoing review of studies on residential satisfaction indicates that the satisfaction or dissatisfaction tend to varies according to housing types, tenure, countries and cultures. Further studies may be required on the theory of acceptance.

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