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The Spatial Visibility within the Low-income Housing Living Unit

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Abstract
The housing quality for the low-income group in Malaysia, especially in Kuala Lumpur, is crucial to improving. Low-income housing design subject to standards by the government has not been satisfactory to the inhabitants' comfort, social and cultural needs. Therefore, this paper aims to explore the relationship between space and users by assessing the visibility of each of the spaces in the units using space syntax as an analytical tool. The study found that the low-income housing design has not considered the visual privacy of private spaces (bedrooms) to common spaces (living and dining areas).

Keywords: Living Units, Low-income Housing, Space Visibility, Space Syntax.

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1.0 Introduction
Malaysia is in Southeast Asia and is one of the fastest developing countries. Greater Kuala Lumpur has over seven million residents. This growing urban population has become pronounced since the 1980s. Consequently, the rapid urbanisation causes the city's increasing number of settlers and slum areas. Low-income Housing (L-iH) schemes such as the People's Housing Project (PPR) have been one of the government's approaches coping with a housing shortage in the cities. The L-iH types in the city comes in the form of high-rise flats, with 13-storeys and 20 living units per floor. According to CIDB (1998) for the L-iH standard, the low-income living units are is 63m^2 fitted with a kitchen, living and dining area, 3-bedrooms and 2 toilets. However, despite the effort by the government to provide housing for the low-income group, most of the studies in the literature mentioned a lack of space consideration given towards L-iH (Nor Haniza Ishak et al., 2016; Razali & Talib, 2013; Wahi et al., 2018). Khazanah Research Institute (2019) also mentions that the current PPR housing design is inadequate and still does not cater to its occupants' basic needs. Gou et al. (2018) addressed that it is essential to provide suitable housing for the low-income group, as the low-income group are most vulnerable to the physical condition of the housing. Besides, the housing environments were the most impactful element for overall quality of life, especially for the L-iH where low-income people live (Bakar et al., 2016; Mohit et al., 2010; Mohit & Nazyddah, 2011). Therefore, this study explores the relationship between users and spaces and identifies the visibility of spaces in L-iH living units. A study was conducted with 3-bedroom PPR units of similar spatial arrangement to explore space visuality in the design. This study is crucial in understanding the relationships between users and the spaces. Hence, this study will benefit developers, consultants, and researchers in the architecture field to determine the parameters to improve L-iH's spatial quality.

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2.0 Literature Review

In Malaysia, despite a continuous effort by the government to improve the quality of life of low-income people by providing houses for these income groups to have better living conditions.The current L-iH design has not achieved the overall satisfaction of its occupants (Mohamad et al., 2018). According to the Department of Statistics Malaysia (2020), there are generally five members in a typical Malaysian family or household, which creates occupancy by room or space between two and six individuals. This situation generates privacy issues within a family with more than four members (Nor Haniza Ishak et al., 2016; Tee & Goh, 2010). In press can also see these significant issues addressing L-iH occupants' discontentment. According to the interviews conducted by Mohd Salleh (2020) with the PPR's occupants for FMT News, in the house of household five members, all three children shared a room to sleep, play and copy clothes every day regardless of the child gender. These articles noted that the current PPR dwelling design had not considered the occupants' spatial needs. Goh & Ahmad (2011) stated that in space design, the designer still fails to adapt the design to the activity pattern and privacy of the occupants. Razali & Talib (2013) investigate the concept of privacy in Islamic and western perspectives by measuring female privacy in L-iH through space planning. The current L-iH design has not considered the female privacy factors.

Houses with inappropriate living space design may physically and mentally damage people. The concept of privacy seen as a basic human need inserted in psychological and social concepts, implies delving into discussion related to different fields of knowledge, particularly in studies related to behaviour and its built environment (Mohd Razali & Talib, 2018). In the built environment, according to Ferreira De Macedo et al. (2021), since the separation of private and public life in the seventeenth century, the house has been regarded as the centre of private life. A house is a symbolic place that provides ideals of domesticity, comfort, and well-being through privacy (Al-Jokhadar & Jabi, 2020). Houses should provide acceptable levels of visual privacy to ensure privacy and intimacy within the house. Thus, spaces within a house should be organised to provide the privacy possible, and the spatial structure of the house is dictated by the need for privacy of the occupants (Ali Mustafa et al., 2010; Alitajer & Molavi Nojoumi, 2016). Past studies by Zalloom (2019), Gou et al. (2018) and Karim (2012) also addresses that it is significant to consider the visual privacy factors in house design. Visual privacy is defined as the ability to carry out everyday activities hidden from outsiders' eyes (Alitajer & Molavi Nojoumi, 2016). Therefore, the house must be designed and built to provide visual privacy and better quality of living conditions for its occupants.

Thus far, much research has been conducted into the meanings of privacy and its determining factors. However, in terms of architecture, accessing the interior environment of private houses to improve design quality comes with several limitations. A solution to this problem is using specialised software packages for analysis and simulation. However, in Malaysia, the use of the space syntax concept was mainly applied to research into the urban structure (Hidayati et al., 2021; Othman et al., 2020; Mansouri & Ujang, 2016; Salwa et al., 2014). Yahaya (2018) compared and studied the spatial configuration with regard to the L-iH in Johor and Malay traditional houses according to the stationary activities of the occupants. However, a gap exists in the application of the space syntax approach, especially regarding the space visibility and visual privacy within the L-iH living units in Kuala Lumpur.

3.0 Methodology

3.1 Space Syntax

The most prevalent view about space is that spatial configuration indicates the common attitudes and the hierarchy of their different levels (Hillier & Hanson, 1984). In the context of this paper, morphology deals with visibility between spaces and the relationship between spaces (Hanson & Zako, 2005). For the space analysis, incorporating the space syntax techniques, one of the measures for visual properties is visual integration from the visual graph analysis (VGA). VGA is based on the average shortest paths from every location in space to another location (Golshan, 2020; Penn, 2003). Therefore, visual integration measures how visible a location in space is from all the other locations of the unit. It describes mainly the visual connections that exist within the unit. In this case, visibility is linked to accessibility – windows are not considered an element of connection but as a full partition. The more visible, the more integrated this location is, therefore the least private (Huang et al., 2019; Ibrahim et al., 2020).

3.2 The case and sample

When planning to study the visibility of the interior space of L-iH living units in Kuala Lumpur, the initial question is what sample of houses may be appropriate data. The study first looks into the latest standard by the government and found that the 3-bedroom PPR Housing Living unit is the latest design standard for L-iH (CIDB, 1998). Next, according to the Ministry of Housing (Department of Statistics Malaysia, 2020), there are 27 PPR Projects that employed the 3-bedroom living unit design standard. Since the L-iH design is strictly according to standards by the local authority thus, the PPR L-iH unit design is a template according to the year it was built. There are two phase of 3-bedrooms living units PPR in Kuala Lumpur. Firstly, PPR L-iH that built from 1999 until 2010. The second is the PPR housing that was built after 2010. From the 27 PPR projects, the study selected PPR Seri Alam to represent the 3-bedroom phase 1 PPR, and the PPR Sentul Murni living unit represents the phase 2 PPR. The PPR living units' selection above is investigated for several reasons. Firstly, to identify the relationship of visual integration of the space layout concerning the spaces in the living units and their visibility. Secondly, to identify rank visual connectivity and integration of all internal space of the living units and the last to identify the visual distribution of space through visibility variables that make up the system of the houses about structuring the spatial configuration.

The space visibility analysis for this study uses the Autodesk CAD software, with every floor layout are redrawn. Next, these floor plan samples are exported and analysed using UCL DepthmapX software. In this software, the floor plan samples are sets with grid size 100mm X 100mm as an observation point. Next, the floor plan is segmented according to the space function in the living units. There are nine (9) and ten (10) respectively of the main functional space in both PPR Seri Alam and PPR Sentul Murni living units. Based on the space function in the living units, the analysis results are recorded by minimum and maximum values. To conclude the degree of visibility of the spaces, a generalisation has been made.

4.0 Findings

Figure 1 and Figure 2 shows the Visual Graph Analysis measure how visually integrated each space is from all immediate spaces. All the data extracted from the graph are recorded into the table, and the data is divided into three (3) categories of visual integration, minimum, moderate, and maximum. High value is present in red and low value present in blue. The higher the value, the more visually integrated and the lower the value, the more visually segregated. Data findings for the visual integration and connectivity of all PPR Seri Alam living unit indoor spaces are recorded below.

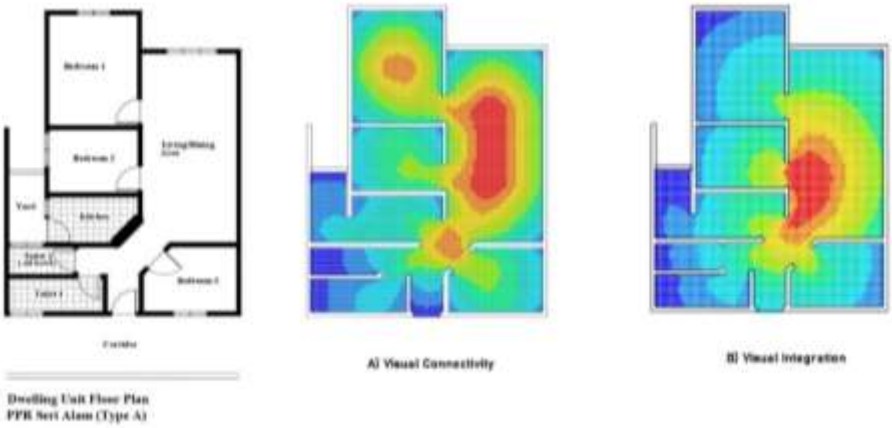

Figure 1. VGA Map of PPR Seri Alam Living unit

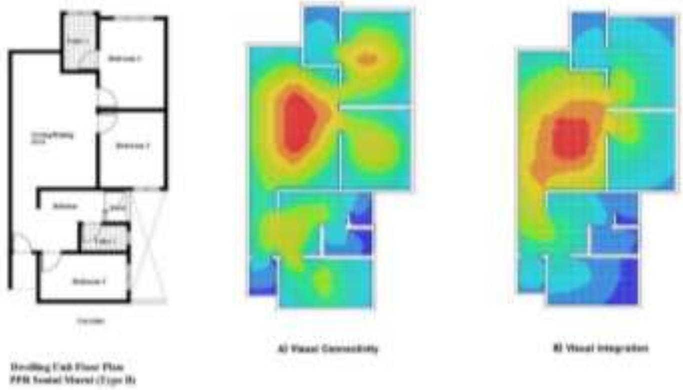

Figure 2. VGA Map of PPR Sentul Murni Living unit

4.1 Visual Connectivity of L-iH living Units

Table 1. Visual connectivity value of all indoor spaces of PPR Seri Alam and PPR Sentul Murni living unit

Spaces/ Nodes	Visual Connectivity Value			
	PPR Seri Alam Living Units		PPR Sentul Murni Living Units	
	Minimum	Maximum	Minimum	Maximum
Foyer (F)	-	-	196	555
Entrance Hallway (E)	206	1033	435	866
Living & Dining Room (LVD)	334	1166	334	1232
Bedroom 1 (B1)	334	946	334	1050
Bedroom 2 (B2)	334	917	334	884
Bedroom 3 (B3)	334	958	326	849
Kitchen (K)	285	851	394	869
Yard (Y)	236	544	166	451
Toilet 1 (T1)	214	453	264	830
Toilet 2 (T2)	178	532	196	486

The minimum visual connectivity data finding is recorded in Table 1. As presented in the table, In the PPR Seri Alam living unit, the nodes LVD, B1, B2 and B3 shared the highest minimum visual connectivity value of 334, followed by node K and node Y with 285 and

236, respectively. Node T1 ranked seventh (217), followed by node E (206). The space that has the least minimum visual connectivity value is node T2. For the PPR Sentul Murni, node E has the highest minimum connectivity value of 435, followed by the node LVD, B1, B2 and B3, which shared a minimum visual connectivity value of 334. Node B3 ranked in the fifth (326), followed by node K in sixth (294) and node T1 (264) in the seventh rank. The nodes F and T2 shared a minimum visual connectivity value of 196. The space with the most negligible minimum visual connectivity value is node Y.

Next, as derived in the table, node LVD's maximum visual connectivity value is the highest (1166) for the PPR Seri Alam, followed by node E (1033). In the third rank is node B3 with 958, followed by node B1 in the fourth with 946. Node B2 and node K ranked in sixth and seventh with 917 and 851, respectively. The node with the least maximum visual connectivity value is T2 and T1, 532 and 453, respectively. Similarly, for the PPR Sentul Murni, node LVD’s maximum visual connectivity value is the highest (1232), followed by node B1 (1050). The third rank is node B2 with the value of 884, followed by node K in the fourth with 869. Node E and node B3 ranked in sixth and seventh with 866 and 849, respectively. The node with the least moderate visual connectivity value is T2 and Y with 486 and 451, respectively.

4.2 Visual Integration of L-iH living Units

Table 2. Visual integration value of all indoor spaces of PPR Seri Alam and PPR Sentul Murni living unit

Spaces/ Nodes	Visual Integration value			
	PPR Seri Alam		PPR Sentul Murni	
	Minimum	Maximum	Minimum	Maximum
Foyer (F)	-	-	2.83	3.40
Entrance Hallway (E)	3.82	7.15	3.81	5.43
Living & Dining Room (LVD)	3.52	7.49	3.55	6.40
Bedroom 1 (B1)	2.80	4.15	2.81	5.32
Bedroom 2 (B2)	3,39	7.06	2.92	5.44
Bedroom 3 (B3)	3.26	6.05	2.38	5.95
Kitchen (K)	3.54	5.95	2.96	4.64
Yard (Y)	2.68	3.65	2.31	2.98
Toilet 1 (T1)	2.82	4.27	2.71	3.69
Toilet 2 (T2)	2.89	4.67	2.31	3.08

As presented in table 2, node E has the highest minimum integration value of 3.82, followed by node K with 3.54. The third rank is node LVD with a minimum integration value of 3.53, and the fourth rank is node B2 with a value of 3.39. Node B3 ranked fifth with a value of 3.26, followed by node T2, T1, and B1 with a minimum visual integration value of 3.89, 2.82 and 2.80, respectively. The space with the least minimum integration value is node Y, with a value of 2.68. Therefore, the entrance hallway is the minimum visually integrated among other living unit spatial system spaces in these findings. The yard of the dwelling is a space function with the least moderate visually integrated among other spaces. For PPR Sentul Murni, node E minimum visual integration value (3.81) is the highest, followed by the node LVD (3.55). The third rank is node K with a minimum visual integration value of 2.96, and the fourth rank is node B2 with a value of 2.92. Node F ranked fifth with 2.83, followed by node B1 and T1 with integration values of 2.81 and 2.71, respectively. The space with the minimum visual integration value is node T2 with 2.31.

Next, node LVD has the highest maximum integration value of 7.49, followed by node E with 7.15 for the PPR Seri Alam living units. The third rank is node B2 with a maximum visual integration value of 7.06 and in the fourth rank is node B3 with the value of 6.05. Node K ranked fifth with 5.95, followed by node T2, T1, and B1 with maximum visual integration values of 4.67, 4.27 and 4.15, respectively. The space with the least maximum integration value is node Y, with a value of 3.65. For the PPR Sentul Murni living units, node LVD has the highest maximum integration value of 6.40, followed by node B3 with 5.95. The third rank is node B2 with a maximum integration value of 5.44 and in the fourth rank is node E with the value of 5.43. Node B1 ranked fifth with 5.32, followed by node K, T1 and F with maximum integration values of 4.64, 3.69 and 3.40, respectively. The space with the most negligible maximum integration value is node Y, with a value of 2.98.

4.3 Overall Space Visual Connectivity and Integration Distribution

The sum of minimum and maximum of both visual connectivity and visual integration is calculated. Next, the percentage of visual connectivity and integration is calculated as shown in the tables and diagram below;

Table 3. Visual Distribution (%) of PPR Seri Alam

Case study	Spaces/ Nodes	Total Visual Connectivity Value (min. + max.)	Visual Connectivity Distribution (%)	Total Visual Integration Value (min. + max.)	Visual Integration Distribution (%)
PPR Seri Alam	Entrance Hallway (E)	1239	14	10.97	14
	Living & Dining Room (LVD)	1500	16	11.01	15
	Bedroom 1 (B1)	1280	13	6.95	13
	Bedroom 2 (B2)	1251	12	7.06	12
	Bedroom 3 (B3)	1292	13	9.31	9
	Kitchen (K)	1136	11	9.49	11
	Yard (Y)	780	8	6.33	8
	Toilet 1 (T1)	667	6	7.09	9
	Toilet 2 (T2)	710	7	7.56	10

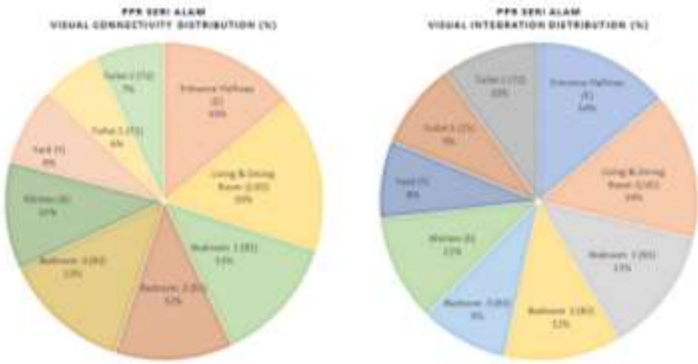

Figure 3. Visual Connectivity and Integration distribution (%) of PPR Seri Alam

Table 4. Visual Distribution (%) of PPR Sentul Murni

Case study	Spaces/ Nodes	Total Visual Connectivity Value (min. + max.)	Visual Connectivity Distribution (%)	Total Visual Integration Value (min. + max.)	Visual Integration Distribution (%)
PPR Sentul Murni	Foyer (F)	751	7	6.23	8
	Entrance Hallway (E)	1301	12	9.24	12
	Living & Dining Room (LVD)	1566	14	9.95	13
	Bedroom 1 (B1)	1384	13	8.13	11
	Bedroom 2 (B2)	1218	11	8.36	11
	Bedroom 3 (B3)	1175	11	8.33	11
	Kitchen (K)	1263	11	7.6	10
	Yard (Y)	617	5	5.29	7
	Toilet 1 (T1)	1094	10	6.4	9
	Toilet 2 (T2)	682	6	5.39	7

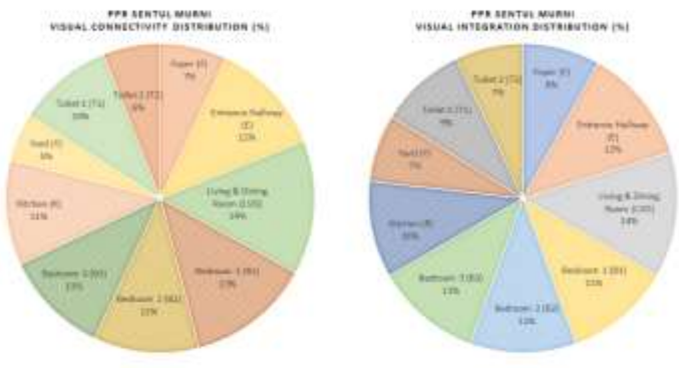

Figure 4. Visual Connectivity and Integration distribution (%) of PPR Seri Alam

For PPR Seri Alam living units, the living and dining room (LVD) has the highest overall visual distribution among other spaces in the living unit with 16% of visual connectivity distribution and 15% visual integration distribution. The Entrance Hallway (E) has the second-highest spatial-visual distribution with 14% visual connectivity and integration value. Bedroom 2 (B2) ranked in the third-highest spatial-visual distribution with 13% visual connectivity and 13% visual integration distribution. The other spaces like Kitchen, Bedroom 3 and Bedroom 1 have moderate overall visual distribution within the unit with 11%, 13% and 13% visual connectivity distribution and 11%, 9% and 12% visual integration distribution, respectively. The toilet 1 (T1) has the lowest overall visual distribution among other spaces in the living unit with 6% of visual connectivity distribution and 9% visual integration distribution. This data shows that the living and dining room has the most spatial visibility in the unit, followed by the entrance hallway and bedroom 2. Conversely, toilet 1 has the least spatial visibility within other spaces in the living unit.

For the PPR Sentul Murni, the living and dining room (LVD) has the highest overall visual distribution among other spaces in the living unit with 14% of visual connectivity distribution and 13% visual integration distribution. The Entrance Hallway (E) has the second-highest spatial-visual distribution with 12% of visual connectivity and integration value. Bedroom 1 (B1) also has the second-highest spatial-visual distribution with 13% of visual connectivity distribution and 11% visual integration distribution. Therefore, Entrance Hallway (E) and Bedroom 1 (B1) ranked second among other spaces in the living unit. The other spaces like Bedroom 2, Bedroom 3 and Kitchen have moderate overall visual distribution within the unit with 11% of visual connectivity distribution and 11%, 11% and 10% visual integration distribution, respectively. The yard has the lowest overall visual distribution among other spaces in the living unit with 5% of visual connectivity distribution and 7% visual integration distribution. This data shows that the living and dining room has the most spatial visibility in the unit, followed by the entrance hallway and bedroom 1. Conversely, the yard has the least spatial visibility within other spaces in the living unit.

Conclusively, the Living and Dining area has the most spatial visibility among spaces in both case studies' living units. Also, in both case studies' living units, the Entrance Hallway has the second most spatial visibility, followed by other spaces in the dwelling. However, for PPR Sentul Murni, bedroom 1 is also the second most spatial visibility among other spaces in the spatial system. On the contrary, both PPR living units have a different space with the least spatial visibility. For instance, in PPR Seri Alam, the yard has the least spatial visibility among other spaces in the spatial system and PPR, Sentul Murni is the Toilet 1.

5.0 Discussion

When the analyses' results are examined, the following data are obtained. Firstly, the most visible spaces are the common spaces in the living units. Common space is defined as a space used by all the household members in the living units. This study found that, in both PPR, the living and dining area are the most visible spaces in the living unit, among other spaces in both living units. Followed by the Entrance hallway ranked second in PPR Seri Alam and ranked third in PPR Sentul Murni. Hillier & Hanson (1984) mentioned that people tend to path their ways according to their visibility. Therefore, the high visibility spaces can be interpreted as spaces with most accessibility and permeability (Zerouati & Bellal, 2019). Thus, the living and dining area are most permeable and easily accessible spaces among other spaces in both living units.

According to Alitajer & Molavi Nojoumi (2016), space with the highest visual connectivity and integration value has the least visual privacy. However, for PPR Sentul Murni, bedroom 1 is also the second most spatial visibility among other spaces in the spatial system. Whereas, in PPR Seri Alam, bedroom 2 (B2) ranked third among the other spaces in the living units. Nevertheless, the high integration and connectivity value in the living room occurs because of its direct connection with the doors of the bedrooms in both living units. Therefore, in other words, once the door opens, the inside of the bedrooms will be visible from the outside (living and dining room) and thus affect the privacy of those who are inside. These also explained that the visual integration and connectivity value of bedrooms 1 and 2 in both living units are among the highest compared to other spaces. Having direct visibility from the common space (living and dining room) to the private space (bedroom) is a concern as the bedroom is a sacred space in a house. Spaces within house should be organised to provide the greatest amount of privacy possible and the spatial structure of the house is dictated by the need for privacy of the occupants (Ali Mustafa et al., 2010; Alitajer & Molavi Nojoumi, 2016). Therefore, the bedrooms and living area should not be directly visually connected to provide better visual privacy within the common space and private space. Thus, this study found no considerations regarding visual privacy within spaces in low-income living units, especially within the bedrooms and the living and dining rooms.

6.0 Conclusion

This paper intended to report the initial findings of ongoing research that explores the spatial configuration of low-income house units and their parameters. Therefore, this study selected the two units of PPR flats in Kuala Lumpur with different spatial layouts. The spatial visibility of all spaces in both living units were quantitively analysed using space syntax. The floor plans were investigated for their visibility of spaces within the living units. It discovered that the living and dining rooms are the most visible space in the unit, among other spaces in both living units. Also, in both case studies' living units, the Entrance Hallway has the second most spatial visibility, followed by the bedrooms in the units. Therefore, these findings revealed that the living and dining room has the least visual privacy, followed by the entrance hallway and bedrooms. However, the visual integration and connectivity value of bedrooms 1 and 2 in both living units are among the highest compared to other spaces as those spaces are adjacent and directly accessible from the living room. Having direct visibility from the common space (living and dining room) to the private space (bedroom) is a concern as the bedroom is a sacred space in a house. Thus, it is important to consider the visual privacy within the L-iH living units as its significance to improve the occupants' quality of life. This study has its limitation, as it only has 3-bedroom low-income living units studies in Kuala Lumpur and the visibility of the space within the living units. Further investigation is recommended regarding the space visibility between the living units from or to the corridor using the space syntax approach.

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Paper Contribution to Related Field of Study

This study provides an exciting opportunity to advance the knowledge of space structure and its quality in Low-income housing in the built environment research as the study analysed the visibility space of current low-income housing design with relation to its occupant's.

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